Port of Seattle

RECEIVED
NOV 28 2012
OFFICE OF
ENVIRONMENTAL CLEANUP

H10ay
HUAR
12.5-5
10/12

EAST WATERWAY OPERABLE UNIT

SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

FINAL REMEDIAL ALTERNATIVE AND DISPOSAL SITE SCREENING MEMORANDUM

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

October 2012

Prepared by

ANCHOR QEA

720 Olive Way • Suite 1900
Seattle, Washington • 98101

Port of Seattle

EAST WATERWAY OPERABLE UNIT

SUPPLEMENTAL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

FINAL REMEDIAL ALTERNATIVE AND DISPOSAL SITE SCREENING MEMORANDUM

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

October 2012

Prepared by

ANCHOR QEA

720 Olive Way • Suite 1900
Seattle, Washington • 98101

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

LIST OF ACRONYMS AND ABBREVIATIONS

Anchor QEA	Anchor QEA, LLC
ARAR	applicable or relevant and appropriate requirements
ASAOC	Administrative Settlement Agreement and Order on Consent
BEHP	bis(2-ethylhexyl)phthalate
BMPs	best management practices
BNSF	Burlington Northern Santa Fe
CAD	confined aquatic disposal
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
City	City of Seattle
cm	centimeter
cm/s	centimeter per second
CMA	Construction Management Area
COC	contaminant of concern
County	King County
Cs-137	cesium-137
CSL	Cleanup Screening Level
CSM	Conceptual Site Model
CSM Report	Conceptual Site Model and Data Gaps Analysis Report (Anchor, Windward and Battelle 2008)
CSO	combined sewer overflow
CSO/SD	combined sewer overflow/storm drain
CWA	Clean Water Act
cy	cubic yard
DDT	dichloro-diphenyl-trichloroethane
DMMP	Dredged Material Management Program
DNR	Washington State Department of Natural Resources
dw	dry weight
Ecology	Washington State Department of Ecology

EIS	Environmental Impact Statement
EISR	Existing Information Summary Report (Anchor and Windward 2008)
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
EW	East Waterway
EWG	East Waterway Group (Port of Seattle, City of Seattle, and King County)
FS	feasibility study
GAC	Granulated Activated Carbon
GRA	General Response Action
H:V	horizontal to vertical
HHRA	Human Health Risk Assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HTTD	high-temperature thermal desorption
IDW	inverse distance weighting
LDW	Lower Duwamish Waterway
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
LTTD	low-temperature thermal desorption
mg/kg	milligrams per kilogram
MHHW	mean higher high water
MLLW	mean lower low water
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
MUDS	Multi-User Disposal Site
NCDF	nearshore confined disposal facility
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
OU	Operable Unit
Pa	Pascals
PAH	polycyclic aromatic hydrocarbon

PCB	polychlorinated biphenyl
PMA	Port Management Agreement
Port	Port of Seattle
POTW	publically owned treatment works
PQL	practical quantitation limit
PRG	preliminary remediation goal
PTM	particle tracking model
RAL	remedial action level
RAO	remedial action objective
RBTC	risk-based threshold concentration
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	remedial investigation
RM	River Mile
ROD	Record of Decision
ROW	right-of-way
Screening Memo	Remedial Alternatives and Disposal Site Screening Memorandum
SD	storm drain
SDOT	Seattle Department of Transportation
SEDGM	Initial Source Evaluation and Data Gaps Memorandum (Anchor and Windward 2009)
SEPA	State Environmental Policy Act
SMS	Sediment Management Standards
SOW	Statement of Work
SQS	Sediment Quality Standards
SRI/FS	Supplemental Remedial Investigation/Feasibility Study
STE	Sediment Transport Evaluation
STER	Sediment Transport Evaluation Report (Anchor QEA and Coast and Harbor 2011)
SVOC	semivolatile organic compound
SWAC	surface-weighted average concentration
T-##	Terminal ##
TBT	tributyltin

TCLP	Toxicity Characteristic Leaching Procedure
TOC	total organic carbon
TSCA	Toxic Substances Control Act
U&A	Usual and Accustomed
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
Windward	Windward Environmental, LLC
Workplan	SRI/FS Workplan (Anchor and Windward 2007)
WSDOT	Washington State Department of Transportation
WW	West Waterway

1 INTRODUCTION

This Remedial Alternatives and Disposal Site Screening Memorandum (Screening Memo) is being prepared as part of the Supplemental Remedial Investigation/Feasibility Study (SRI/FS) for the East Waterway (EW) Operable Unit (OU) of the Harbor Island Superfund Site (Figure 1). The Screening Memo identifies and screens remedial technologies (e.g., dredging, capping) that may be applicable to the EW OU. It also screens potential disposal technologies for contaminated sediment, and includes development of preliminary remedial alternatives to narrow the range of alternatives to be considered for detailed analysis in the Feasibility Study (FS). This Screening Memo satisfies required deliverables set forth in the SRI/FS Workplan (Workplan; Anchor and Windward 2007), prepared in response to the Administrative Settlement Agreement and Order on Consent (ASAOC) and Statement of Work (SOW; EPA 2006), including preparation of a Disposal Site Alternatives Identification and Screening Memorandum and Remedial Alternatives Screening Memorandum.

This Screening Memo also includes development of preliminary site-specific remedial action objectives (RAOs). The RAOs are narrative statements that are medium- or area-specific goals for protecting human health and the environment. RAOs describe in general terms what the sediment cleanup will accomplish for the site, help focus the development of remedial alternatives, and form the basis for establishing preliminary remediation goals (PRGs). PRGs are numeric concentrations or ranges of concentrations of risk drivers (i.e., indicator hazardous substances) in environmental media associated with each RAO.

The purpose for developing preliminary RAOs and screening of remedial alternatives and disposal sites is to efficiently eliminate remedial technologies, disposal options, and alternatives that are not practicable so the FS can focus on viable remedial alternatives. This approach is consistent with U.S. Environmental Protection Agency (EPA) RI/FS guidance (EPA 1988) and contaminated sediment remediation guidance (EPA 2005). Site conditions and existing and future uses within the EW may limit the remedial alternatives that are feasible and will be factored into the evaluation of both disposal site and remedial alternatives in this preliminary evaluation.

1.1 Background and Regulatory Framework

The EW is one of seven OUs of the Harbor Island Superfund site, which was added to EPA's National Priorities List (NPL) in September 1983 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund. As described in EPA's Superfund regulations (1988), EPA requires that an RI/FS be conducted for each site listed on the NPL, and thus EPA has ordered the Port of Seattle (Port) to conduct a SRI/FS for the EW OU. Under the oversight of EPA, the EW SRI/FS is being conducted by the East Waterway Group (EWG), which consists of the Port, the City of Seattle (City), and King County (County). The Port signed the ASAOC with EPA in October 2006, and subsequently signed a Memorandum of Agreement with the City and County to conduct the SRI/FS. The SRI/FS will ultimately lead to an EPA Record of Decision (ROD) outlining cleanup actions to address threats to human health and the environment in the EW. For purposes of the SRI/FS, the EWG will be referenced as the entity managing the project under EPA oversight.

1.2 Objectives of Screening Memo

The objectives of the Screening Memo are listed below:

- Develop preliminary narrative RAOs that address the primary exposure pathways, receptors, and risk drivers, based on the current understanding of the EW OU. Risk drivers will be finalized as part of the final Baseline Human Health Risk Assessment (HHRA) and final Baseline Ecological Risk Assessment (ERA) in 2012. Human health exposure pathways include consumption of seafood from the EW; direct contact with sediment (through incidental ingestion and dermal contact) during commercial netfishing, habitat restoration, and clam harvesting in the EW; and direct contact with surface water (through incidental ingestion and dermal contact) while swimming in the EW. Ecological exposure pathways include sediment contact, sediment ingestion, water contact, water ingestion, and prey ingestion.
- Identify and screen candidate remedial technologies to eliminate those that cannot be implemented due to technical or other constraints at the site.
- Identify and screen contaminated sediment disposal technologies to eliminate those that cannot be implemented due to technical or other constraints at the site.
- Assemble the retained technologies into potential remedial alternatives.

- Evaluate and eliminate alternatives that are impractical and cannot be implemented at the site.

After completion of the preliminary screening of alternatives, further analysis of the retained alternatives will occur as part of the detailed evaluation in the FS Report. The FS will further refine the alternatives as necessary, analyze the alternatives against CERCLA evaluation criteria, and compare the alternatives against one another. Specific remedial or disposal technologies eliminated in this Screening Memo may be reintroduced in the FS or during remedial design if conditions change or specific remedial or disposal technologies become more viable.

1.3 Screening Memo Assumptions

A number of assumptions apply to the preliminary screening conducted as part of this Screening Memo, as described below:

- The preliminary screening relies on the current understanding of physical conditions that affect sediment stability; the distribution of surface and subsurface sediment contamination; and primary exposure pathways, receptors, and risk drivers. This dataset includes information contained in the Draft Sediment Transport Evaluation Report (STER; Anchor QEA and Coast and Harbor 2011) and surface and subsurface sediment data reports generated for the site. The spatial extent of surface sediment contamination is based on evaluations included in the Draft Baseline ERA (Windward 2011a), which is based largely on the Final Surface Sediment Data Report (Windward 2010a) and historical surface sediment data that has not been removed or buried through historical thin-layer sand placement (Anchor and Windward 2005). The vertical extent of contamination is based on subsurface sediment data presented in the Final Subsurface Sediment Data Report (Windward 2011b). The Draft Baseline ERA (Windward 2011a) and Draft Baseline HHRA (Windward 2011c) established primary exposure pathways, receptors, and risk drivers, which have led to the conclusion that sediment cleanup is required.
- PRGs for risk driver contaminants and remedial action levels (RALs) have not yet been identified. The baseline risk assessments have not yet been finalized. Although preliminary RAOs are defined in this Screening Memo (based on the working RAOs

for the Lower Duwamish Waterway [LDW] site), they may be refined in the RAO Memorandum and in the FS Report. This document uses the Sediment Quality Standards (SQS) numerical criteria of the Washington State Sediment Management Standards (SMS) as a surrogate for RALs to identify potential remedial areas. The SMS numerical criteria provide marine sediment standards for the protection of benthic invertebrates, but not for the protection of human health or for some other ecological receptors (RAOs are discussed in Section 3). RALs are cleanup levels for specific remedial activities as part of final remedial action. PRGs are the preliminary cleanup goals defined in the FS. Final RALs and final cleanup goals for final remedial action (the latter typically based on PRGs) will be selected by EPA in its ROD. Use of the SMS numerical criteria provides a consistent basis for developing and evaluating conceptual remedial action alternatives independent of the final cleanup decisions. All contaminants of concern (COCs) and conclusions (including changes to risk assessment assumptions) identified in the final risk assessments will be addressed in the FS, as well as appropriate RALs.

- This Screening Memo principally evaluates detected contaminants that are listed in the Washington State SMS (Washington Administrative Code [WAC] 173-204) using the project database. For this document, the baseline sediment contaminant concentrations were those compiled through 2010 by Windward Environmental, LLC (Windward) for SMS chemicals. These data included all surface sediment results included in the Draft Baseline ERA (Windward 2011a) and subsurface sediment results from the Final Subsurface Sediment Data Report (Windward 2011b). Additional historical subsurface sediment data may be included for evaluation in the FS pending completion of the SRI Report.
- Potential remedial areas were developed based on all detected SMS contaminants. The evaluation of other COCs (e.g., dioxin/furan and tributyltin [TBT]) is not included in this screening. The SMS chemicals are used as a surrogate for the risk drivers exceeding the "to be determined" RALs. All COCs and associated pathways of human health or ecological risk identified by the final risk assessments, including those not on the SMS list, will be addressed in the FS.

The assumptions identified above are necessary to perform the screening described in this Screening Memo. Although the remedial footprint, which will be developed in the FS, is not available at this time, it is not anticipated that decisions to eliminate disposal technologies, remedial technologies, and remedial alternatives evaluated in this Screening Memo will need to be revisited during the FS, unless conditions change or specific remedial or disposal technologies become more viable, in which case specific technologies may be reintroduced in the FS or during remedial design.

1.4 Document Organization

The remainder of this document is organized as follows:

- **Section 2** presents the basis for the screening evaluation, including physical site characteristics of the EW, habitat and biological communities, structures and utilities, and human use characteristics for the EW and surrounding land and preliminary nature and extent of contamination summaries
- **Section 3** presents the development of preliminary RAOs
- **Section 4** provides the identification of preliminary remedial technologies
- **Section 5** provides a presentation of the preliminary alternatives
- **Section 6** provides summary and conclusions
- **Section 7** provides cited references

2 BASIS FOR THE EVALUATION

It is important to consider site conditions when evaluating and selecting potential remedial technologies for a cleanup site. This section summarizes key site condition information relevant to the development of remedial alternatives. This includes information presented previously in the Existing Information Summary Report (EISR; Anchor and Windward 2008), Conceptual Site Model and Data Gaps Analysis Report (CSM Report; Anchor, Windward, and Battelle 2008), as well as additional reports provided to EPA including the Final Surface Sediment Data Report (Windward 2010a), Final Subsurface Sediment Data Report (Windward 2011b), Draft Baseline HHRA (Windward 2011c), Draft Baseline ERA (Windward 2011a), and other data reports provided to EPA on which the risk assessments were based, as listed below:

- East Waterway Human Access Survey Report (Windward 2008)
- Final Data Report: Benthic Invertebrate Tissue and Co-located Sediment Samples (Windward 2009a)
- Final Surface Water Data Report (Windward 2009b)
- Data Report: Clam Survey, Geoduck Survey, Fish and Shellfish Tissue Collection PCB Congener and Dioxin/Furan Results (Windward 2010b)
- Data Report: Clam Surveys and Sampling of Clam Tissue and Sediment (Windward 2010c)
- Data Report: Fish and Shellfish Tissue Collection (Windward 2010d)
- Data Report: Juvenile Chinook Salmon Tissue Collection (Windward 2010e)
- Data Report: Surface Sediment Sampling for Chemical Analyses and Toxicity Testing (Windward 2010f)

In addition, a brief summary of information on site hydrodynamics developed in the Draft STER (Anchor QEA and Coast and Harbor 2011) is discussed in this section. More detailed discussions of site condition can be found in the above-referenced reports. The FS will be based on the presentation of this information in the EW SRI.

2.1 Physical Site Characteristics

2.1.1 Hydrodynamics

The EW is located approximately 1 mile southwest of downtown Seattle, in King County, Washington. It is part of the greater Duwamish River estuary, which includes the freshwater/saltwater interface extending as far as 10 miles upstream from the mouth at Elliott Bay.

The EW receives freshwater flows from the Green/Duwamish River watershed. The Howard Hanson Dam impounds the Green River at River Mile (RM) 64.5 (USACE 2005) and was constructed to provide flood control in the Lower Green River (USACE 2007). The Green River becomes the Duwamish River at the confluence of the Green River and Black River. The Duwamish River drains approximately 362,000 acres, flowing northward to its terminus in Puget Sound at Elliott Bay.

At the southern end of Harbor Island, the northward flowing Duwamish River splits into the EW and the West Waterway (WW). The EW and WW extend from the southern end of Harbor Island to the island's north end at Elliott Bay. The EW runs along the eastern shore of Harbor Island. The EW is subject to tidal forcing from Elliott Bay, which is characterized by mixed semi-diurnal tides (two high and two low tides per day that are not equal in height). The average tidal range (mean lower low water [MLLW] to mean higher high water [MHHW]) measured at the Seattle waterfront is 11.36 feet. The highest and lowest expected tidal heights are +13 and -3.5 feet MLLW, respectively (National Oceanic and Atmospheric Administration [NOAA] Station ID 9447130).

The EW also receives freshwater discharges from 39 outfalls (Figure 2). The discharges are intermittent, and the relative contribution of freshwater from the outfalls is small in comparison with flows from the Duwamish River. These outfalls are a primary source of lateral contributions of contamination (as opposed to upstream contamination). Contributions from lateral sources must be considered in the evaluation of recontamination potential and long-term effectiveness of any remedy. Detailed evaluations of contaminant sources are not included in this Screening Memo, but will be evaluated in the FS as part of recontamination potential.

A complete summary of the hydrodynamic modeling conducted in the EW is included in the STER (Anchor QEA and Coast and Harbor 2011). A more detailed summary of the Physical Processes Conceptual Site Model (CSM) is included in Section 2.4 of this Screening Memo. The Physical Processes CSM will also be presented in the SRI Report.

2.1.2 Bathymetry and Navigation/Berthing Elevations

The main body of the waterway is 750 feet wide; the federal navigation channel is 450 feet wide and has an authorized elevation of -51 feet MLLW (Figure 2). The most recent bathymetric survey within the EW was conducted in January 2010. Current bathymetry within the federal navigation channel shows that the authorized elevation of -51 feet MLLW is met from Station 0 (i.e., mouth of the EW) to Station 4950 (i.e., 4,950 feet upstream of the mouth of the EW), with the exception of a small area near the southern entrance of Slip 27 (e.g., the "mound" area). Some areas within the northern portion of the federal channel reach -60 feet MLLW. Bathymetry in areas north of the northern EW OU study boundary (i.e., within Elliott Bay) quickly become much deeper than -60 feet MLLW, reaching elevations deeper than -200 feet MLLW. Along Terminal 18 (T-18), elevations south of Station 4950 generally decrease to -37 feet MLLW. Along T-25 (Stations 4600 to 6150), elevations in the berth area are approximately -50 feet MLLW. Mudline elevations rise to between -11 and -4 feet MLLW in the vicinity of the Spokane Street corridor; the sediments comprising the sill under and between the bridges within the Spokane Street corridor have never been dredged, based on historical records from the U.S. Army Corps of Engineers (USACE).

Port operational berthing elevation requirements vary based on location in the EW. Along T-18 between Berths 1 and 5 (Station 0 through 4950), the berthing elevation requirement is -51 feet MLLW. Along T-25 and T-30, berthing elevation requirements are -50 feet MLLW. The Port's requirement for berthing in Slip 27 is generally -40 feet MLLW. In Slip 36, U.S. Coast Guard (USCG) berthing requirements are generally -40 feet MLLW. Dredging activities conducted since 2000 to maintain required navigation and berthing elevations are shown on Figure 3.

2.1.3 Sediment Characteristics

A summary of existing grain size, total solids, and total organic carbon (TOC) data is presented in the EISR (Anchor and Windward 2008), Final Surface Sediment Data Report (Windward 2010a), and the Final Subsurface Sediment Data Report (Windward 2011b). These data indicate that most sediment samples consisted primarily of clay and silty sand, with an average of approximately 40% sand and 50% fines (total silt and clay). More fines are present in sediments in the central and northern portions of the EW than in the vicinity of the Spokane Street corridor. Total solids content is generally between 40% and 60%. Surface sediments contain less than 2% TOC over nearly all of the EW, with small patches above 2%, including Slip 27. Additional information on lithology and stratigraphy of the EW are detailed in the Final Subsurface Sediment Data Report (Windward 2011b).

2.1.4 Existing Structures

The EW shoreline is highly developed, primarily composed of over-water piling-supported piers, riprap slopes, seawalls, and bulkheads for industrial and commercial use. Throughout the entire length of the EW, approximately 60% of the EW shoreline contains over-water piers (aprons) above riprap slopes (along T-18, T-25, T-30, T-46, and in Slips 27 and 36; see Figure 4). Another 30% contains exposed shoreline armored with riprap (including the entire area south of the Spokane Street Bridge corridor; Figure 4). The remaining 10% is comprised of steel sheetpile bulkheads (Figure 4).

Four bridge structures pass over the southern end of the EW in the Spokane Street Bridge corridor that are operated and maintained by the Seattle Department of Transportation (SDOT; Spokane Street Bridge and Service Road Bridge between T-102 and T-104), Washington State Department of Transportation (WSDOT; West Seattle Bridge), and Burlington Northern Santa Fe (BNSF) Railway (Railroad Bridge). A 34-foot-wide truck bridge is also present across the head of Slip 27 between T-25 and T-30. Further information on existing structures is contained in the EISR (Anchor and Windward 2008).

2.2 Waterway Uses

2.2.1 Adjacent Facilities and Infrastructure

Land use, zoning, and land ownership along the EW are consistent with active industrial uses (Figure 5). The sides of the EW contain hardened shorelines with extensive overwater structures, commercial and industrial facilities, and other development (Figure 4). The EW is an industrial waterway used primarily for container loading and transport.

Thirty-nine outfalls are present in the EW, including 36 storm drains, one combined sewer overflow (CSO), and two combined sewer overflow/storm drains (CSO/SDs; Figure 4). The two outfalls that are shared by separated storm drains and CSOs are the South Hinds Street and South Lander Street outfalls. These CSO/SD outfalls and the Hanford CSO outfall discharge along the eastern shoreline of the EW. The stormwater-only outfalls are located along both sides of the waterway.

A communication cable crosses the EW between T-18 and the northern portion of T-30 (Figure 4). This cable was originally buried between -61 and -66 feet MLLW in 1972 in an armored trench. The location shown on Figure 4 is based on design drawings; however, this cable may have been moved slightly from that location by a vessel anchor based on reports from a marine contractor that located the cable as part of underwater bulkhead construction in 2003 (Oates 2007).

Further information on adjacent facilities and infrastructure is found in the EISR (Anchor and Windward 2008).

2.2.2 Navigation and Berthing

The EW north of the Spokane Street corridor experiences regular vessel traffic of various sizes and types. Most vessel traffic consists of shipping companies moving container vessels and assorted tugboats into and out of the EW. Each container ship requires at least one tugboat to maneuver the ship during docking and undocking. Container ships call at T-18, T-25, and T-30.

Numerous barges and tugboats are moored at the head of the EW along Harley Marine Services, which includes Olympic Tug and Barge as a subsidiary (Figure 5). At the north end, along T-18, tug and barge traffic utilize the Kinder Morgan petroleum products transfer facility (Figure 5).

Additional navigation and berthing occurs in Slips 27 and 36. Slip 27 is used by the Port for temporary moorage of barges (along Pier 28), which are maneuvered by tugboats. USCG vessels frequent Slip 36, which serves Pier 36 (south) and Pier 37 (north). All of Slip 36 is owned by USCG. USCG moors numerous vessels in Slip 36, including USCG Icebreakers, Cutters (greater than 65 feet in length), and gunboats. Only USCG vessels use this slip.

South of the Spokane Street corridor, recreational and commercial boats access the Harbor Island Marina (T-102) from the LDW. Along the T-102 shoreline within the EW, the 750-foot-long dock is used for commercial moorage.

2.2.3 Aquatic Land Ownership

The main body of aquatic land in the EW is owned by the State of Washington and managed by the Washington State Department of Natural Resources (DNR) between the pierhead lines (Figure 5). Land located within the pierhead line is state-owned but managed by the Port through a Port Management Agreement (PMA). This area includes all aprons that extend approximately 100 feet from the Port's upland parcel boundary.

Several aquatic areas within the EW are not state-owned. South of the Spokane Street corridor, the Port owns the entire width of the EW. The Port also owns all of Slip 27, including the vacated portion of the South Forest Street right-of-way (ROW) and Pier 27 (south side of Slip 27). A portion of aquatic area along Pier 24 that formerly contained timber decking is also owned by the Port. All of Slip 36 is owned by USCG.

2.2.4 Tribal and Recreational

Commercial netfishing operations are conducted in the EW by the Muckleshoot Tribe. The EW is part of the Suquamish and Muckleshoot Tribe's Usual and Accustomed (U&A) fishing grounds; consequently, they reserved their right under federal treaties to harvest salmon in commercial quantities from this area and use the waterway for ceremonial and subsistence fishery.

The EW is not a major area for recreational use compared to other water bodies in and around Seattle (King County 1999). Recreational boating in the EW occurs on a limited basis. No boat ramps are present in the EW, but water access is provided at Jack Perry Memorial Shoreline Public Access (on the eastern side of the EW, south of Slip 36) for kayakers and other non-motorized watercraft. Harbor Island Marina provides recreational boat moorages along the EW and in the LDW and WW. Harbor Island Marina moorages in the EW are mostly used for commercial boats, but small recreational boats may enter from the LDW. The presence of the Spokane Street Bridge and the Railroad Bridge prohibit most boat passage, except at low tide by small, shallow-draft boats (e.g., kayaks and skiffs).

Although there are currently fish advisories posted (for seafood other than salmon), fishing and crabbing are conducted from the north side of the Spokane Street Bridge, especially during summer and fall salmon runs. Fishing has also been observed north of the eastern side of the Spokane Street Bridge from the riprap slopes during summer salmon runs.

Few data have been located quantifying the frequency with which people use the EW for recreational purposes other than fishing. Few people, if any engage in water activities such as swimming, SCUBA diving, and windsurfing within the EW. Such uses are likely to continue to be limited by the active commercial use of the EW, the very limited public access due to security requirements of container terminals and the USCG facility, and the availability of nearby areas that provide superior recreational opportunities.

2.2.5 Ecological Functions

Dredging and development over the past 100 years have substantially altered nearshore environments in Elliott Bay and the Duwamish River estuary. Currently there is no natural shoreline in the EW. The aquatic habitats found in the EW are intertidal and subtidal, and water column habitats. Numerous infaunal and epibenthic invertebrate species inhabit the intertidal and subtidal substrates of the EW. Larger invertebrates also inhabit the EW; these include crabs (Dungeness crabs [*Cancer magister*], red rock crabs [*Cancer productus*], graceful crabs [*Cancer gracilis*]), arthropods, and echinoderms. Bivalves identified in the EW include blue mussel (*Mytilus* spp.), butter clam (*Saxidomus gigantea*), cockle (*Clinocardium nuttali*), eastern soft-shell clam (*Mya arenaria*), geoduck (*Panopea generosa*), Japanese littleneck clam (*Venerupis* [= *Tapes*] *philippinarum* [= *japonica*]), macoma clam (*Macoma* spp.), and native littleneck clam (*Leukoma* [= *Protothaca*] *staminea*). Diverse populations of fish, including 42 anadromous and resident fish species, also reside in or use the EW as a migration corridor. There is very little information on bird and mammal populations in the vicinity of the EW; however, the relatively large home ranges associated with many bird and mammal species make the LDW data relevant to the EW. The LDW habitats support a diversity of wildlife species. Previous studies have reported 87 species of birds, 3 species of marine mammals, and 3 species of aquatic-dependent terrestrial mammals that use the LDW at least part of the year to feed, rest, or reproduce (Windward 2003). These functional habitats and species are considered in this Screening Memo with respect to alterations of the physical nearshore environment (e.g., effects of the alternatives on existing mudline elevations and substrates) and the allowable in-water work windows to protect migrating juvenile salmonids.

Areas within the EW that have been restored or may be restored in the future to enhance habitat conditions are listed below:

- In the Junction Reach, habitat restoration was conducted with the creation of a shallow bench along the eastern shoreline at T-104, which was constructed of fine-grained substrate and provides valuable shallow water habitat for juvenile migratory fish and intertidal areas for clams.
- In the Sill Reach, habitat restoration is proposed for the west side of the EW under the West Seattle Bridge, which would provide off-channel mudflat and marsh habitat, along with riparian vegetation. The restoration project would also involve removal of debris and creosote structures from the shoreline areas. The restoration is subject to Natural Resource Damage Trustee approval and EPA coordination. Construction could occur as early as 2012.
- Just north of the Spokane Street Bridge, a mound of fill stabilized by rock was placed specifically for habitat restoration purposes. This mound provides shallow water and intertidal habitat.

- The piling field located adjacent to Pier 24 is also an area targeted for possible future habitat restoration. Restoration in this area could potentially be implemented in combination with whatever remedial action is selected for this area.
- The bank along the southern part of Slip 27 has been replanted in an effort to restore natural habitat conditions to this area. The restoration extends from the top of bank (18.5 feet MLLW) down to 12 feet MLLW.
- Jack Perry Park is a 1.1-acre park located north of T-30 and south of the USCG facility. It was constructed as mitigation for a street vacation, and provides 120 feet of intertidal area and shoreline access for public recreational activities, and as such provides an area for potential future habitat enhancements.

2.3 Major Similarities and Differences to Lower Duwamish Waterway

The LDW Superfund Site is located immediately adjacent to the EW to the south. The similarities between the LDW and EW make a number of previous evaluations conducted for the LDW CERCLA process pertinent to the EW CERCLA process. This includes previous evaluations conducted to screen remedial technologies in the LDW (i.e., *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* [RETEC 2005]), in which many remedial and disposal technology evaluations are pertinent to the EW. However, there are also important differences between the two waterways, which necessitates a different approach and/or evaluation for the EW than what was conducted for the LDW. This section describes the major similarities and differences between the two waterways.

The LDW and EW share many similar characteristics considering they are both parts of the Green/Duwamish River system and both are influenced by tidal exchange from Elliott Bay. Given its proximity to Elliott Bay, the EW is more heavily influenced by marine tidal exchange, but contains a freshwater layer at the surface. The LDW is estuarine and more heavily influenced by freshwater flow conditions. It contains a salt-water wedge that can move from Harbor Island to approximately 4.7 miles upstream from Harbor Island (Windward 2010g); however, the downstream parts of the LDW tend to resemble the EW more than the upstream parts. Both waterways receive freshwater contributions from the Green River and lateral inputs from stormwater outfalls and CSOs, but the LDW receives input from freshwater streams, and the EW does not.

The EW is also generally much deeper than the LDW, with the EW's bed elevation at approximately -51 feet MLLW or deeper in approximately 60% of its area. The EW has a federal navigation channel that is authorized for -51 feet MLLW. The LDW's federal navigation channel (deepest bed elevation in the LDW) is maintained at -30 feet MLLW from Harbor Island to the 1st Avenue S Bridge, -20 feet MLLW from the 1st Avenue S Bridge to Slip 4, and -15 feet MLLW from Slip 4 to the Upper Turning Basin (NOAA 2009). Both the LDW and EW experience extensive vessel traffic; however, the EW can accommodate much deeper draft vessels, such as container ships, than the LDW.

The LDW contains more natural intertidal, shallow subtidal, and nearshore areas with riparian vegetation than the EW. The differences in salinity, water depth, and shoreline features contribute to some differences in the observed benthic, fish, clam, crab, and mussel communities in each area, although most observed organisms are present in both the EW and the LDW. Each waterway is within Tribal U&A fishing areas and, thus, both are used for tribal commercial, ceremonial, and subsistence seafood harvesting. The LDW also has more public access areas than the EW.

Approximately 43% of the subwatershed area of the LDW is used for commercial/industrial purposes, and approximately 39% is residential (King County 2005). The remaining 18% consists of undeveloped, natural areas. For the EW, 100% of the adjacent upland area has industrial and commercial use. The EW also has a significantly higher percentage of over-water structures than the LDW. Approximately 60% of the EW shoreline has over-water piers (aprons) built on riprap armored slopes, compared to approximately 15% of the LDW shoreline. Approximately 70% of the LDW is open shoreline, with a combination of natural bank and armored slopes. Approximately 30% of the EW shoreline is open shoreline, but nearly all of the open shoreline is armored with riprap. The remaining 10% of the EW shoreline contains bulkheads, compared to 15% bulkhead armoring of the LDW shoreline (Terralogic and Landau 2004).

Finally, while the LDW had early action areas identified and early actions conducted prior to the completion of the RI/FS and ROD, the EW currently does not have any early action areas planned.

2.4 Potential Sources and Pathways of Contamination

Potential sources and pathways of contamination to the EW were summarized in the Initial Source Evaluation and Data Gaps Memorandum (SEDGM; Anchor and Windward 2009), and include stormwater, CSOs, groundwater-to-sediment pathways associated with nearshore cleanup sites, creosote-treated structures, atmospheric deposition, spills, and banks. Detailed information on each potential source will be included in the SRI Report. This Screening Memo does not evaluate recontamination potential from sources, but this evaluation will be part of the FS.

2.5 Nature and Extent of Contamination

Based on the findings of the Draft Baseline ERA (Windward 2011a) and Draft Baseline HHRA (Windward 2011c), unacceptable risk from exposures to sediment and from consumption of seafood exists in the EW. Therefore, sediment remediation will be required. For the purposes of the Screening Memo, the COCs that will be used to identify sediments that might require remediation are assumed to be the contaminants exceeding SMS. The horizontal and vertical distributions of these COCs within the EW sediments are considered in this Screening Memo, primarily to estimate the area and thickness of sediments containing concentrations of contaminants that may require remediation. The FS will evaluate all COCs with a focused evaluation using risk drivers identified in the Final HHRA and Final ERA. Use of SMS to identify sediments that might require remediation is appropriate for this screening exercise given the similarity in distribution of SMS and non-SMS COCs (e.g., dioxin/furan and TBT) in the EW. The areas with the highest concentrations of non-SMS COCs also have the highest concentrations of SMS contaminants, and the areas with the lowest concentrations of non-SMS COCs also have the lowest concentrations of SMS contaminants. The sections below present a summary of the surface and subsurface sediment contamination in relation to the SMS.

2.5.1 Surface Sediment Data

Surface sediment data that represent baseline conditions are available from samples collected from 243 sample locations within the EW from 1995 through the most recent 2009 SRI sampling event. These samples include data for metals, mercury, TBT, total polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), organo-chlorine compounds, and dioxins/furans. As noted earlier, for purposes of this Screening Memo, SMS chemicals are the focus of this analysis. Of the 243 locations, 167 locations had one or more detected exceedances of the SQS. Total PCBs most frequently (65%) exceeded its SQS criterion, followed by mercury (19%), and 1,4-dichlorobenzene (13%). All other contaminants exceeded their respective criteria in less than 10% of the locations. Twenty-three contaminants exceeded their respective Cleanup Screening Level (CSL) in at least one location, with total PCBs being the most frequently detected above its CSL criterion (23 of 240 locations, or 9.6%) followed by mercury (10 of 239 locations, or 4.2%).

Figure 6 shows the SMS designations based on chemistry concentrations for all locations, as represented by Thiessen polygons. Based on these polygons, the percentage of the EW area with contaminant concentrations below SQS is approximately 27%, and the percentage of the area in which adverse effects are expected occur (i.e., greater than CSL) is approximately 20%. Approximately 53% of the area contains contaminant concentrations between the SQS and the CSL (i.e., greater than SQS and less than or equal to CSL). For purposes of screening technologies and preliminary alternatives, areas with detected surface sediment chemistry exceeding SQS standards are used to develop remedial action alternatives for this Screening Memo and are discussed further in Section 5.

2.5.2 Subsurface Sediment Data

Subsurface sediment data that represent current subsurface conditions are available from samples collected from 146 locations within the EW, from 1995 through the most recent 2010 SRI sampling event. The Final Subsurface Sediment Data Report (Windward 2011b) and EISR (Anchor and Windward 2008) provide details on subsurface sediment characteristics, and the SRI Report will contain information on all retained subsurface sediment data.

This Screening Memo relies on the 65 locations collected as part of the SRI investigation in 2010. Of those locations, 50 had at least one sample with an exceedance of an SMS criterion in one sample interval (Figure 7). Based on the SRI sampling, the greatest number of exceedances were due to total PCB (based on Aroclors) and mercury concentrations in subsurface sediment in the EW.

Total PCB concentrations exceeded the SQS but not the CSL in 36 of the 165 samples, and exceeded the CSL in 43 of the 165 samples. Thirty locations contained at least one sediment interval with total PCB concentrations above the CSL, and 20 locations contained a sediment interval with total PCB concentrations above the SQS and no CSL exceedances.

Mercury concentrations exceeded the SQS but not the CSL in 23 of the 179 samples tested, and the CSL in 44 of the 179 samples. Twenty-seven locations contained at least one sediment interval with mercury concentrations above the CSL, and six locations contained a sediment interval with mercury concentrations above the SQS but no CSL exceedances. Metals other than mercury that exceeded the SMS criteria include cadmium, copper (one sample), lead (six samples), silver (three samples) and zinc (16 samples).

Of the 150 subsurface sediment samples analyzed for polycyclic aromatic hydrocarbons (PAHs), concentrations of total high-molecular-weight PAHs (HPAHs) exceeded the SQS but not the CSL in seven samples (two locations) and exceeded the CSL in seven samples (five locations). The detected concentrations of the low-molecular-weight PAHs (LPAHs) exceeded the SQS but not the CSL in six samples (two locations) and exceeded the CSL in seven samples (two locations).

Of the 146 subsurface sediment samples analyzed for phthalates and other SVOCs, bis(2-ethylhexyl) phthalate (BEHP) exceeded the SQS and not the CSL in 17 samples (12 locations), and exceeded the CSL in nine samples (nine locations). Other SVOCs that exceeded the SQS in at least one sample included butyl benzyl phthalate (seven samples); 1,2,4-trichlorobenzene (three samples); 1,4-dichlorobenzene (nine samples); 2,4-dimethylphenol (five samples); 2-methylphenol (one sample); and n-nitrosodiphenylamine (two samples).

2.5.3 Evaluation of Vertical Extent of Contamination

The vertical extent of contamination was estimated at each of the 65 sediment cores collected as part of the SRI sampling in 2010. Because RALs have not yet been defined, SQS has been used as a surrogate for defining the depth of contamination.

The SRI database includes sample results collected from cores from 1991 through 2010; however, cores collected before 2010 consist of composites of sediment over large intervals (e.g., 4-foot intervals). In addition, many of the historical cores were located in areas that had been dredged. As a result, the analysis of vertical extent of contamination was conducted using cores collected as part of the SRI sampling in 2010 because it provides good spatial coverage of the EW and a more accurate measure of the elevation of contamination based on sample intervals of 1 to 2 feet thick. Sample thickness in each sediment core was corrected from ex situ depths to the in situ depth (corrected for compaction during processing).

For each core, the thickness of contaminated sediment was measured for all sediment above SQS criteria. For sediment above SQS criteria, when moving from the top of a core to the bottom, if a sample interval exceeded SQS for any SMS parameter and the next lowest sample and all other samples below were less than SQS for all SMS parameters, the top of the interval below SQS was established as the "clean" elevation of that core. As a conservative approach, in instances where a sample interval was not tested between a sample exceeding SQS criteria (above) and a sample less than SQS criteria (below), the top of the lower tested interval below SQS criteria was identified as the "clean" elevation for that core. In only one core (EW10-SC29), each interval exceeded SQS criteria; therefore, in that core, the bottom of the deepest sample was used as the maximum depth of contamination (the lowest sample was collected from native material). The contaminated thickness and elevation of each core was calculated and is presented in Table 1. Using this data, a "clean" neatline surface was created using inverse distance weighting (IDW) in GIS, which provides a general understanding of the extent of subsurface contamination throughout the site. The boundaries for the IDW interpolation followed the EW study boundary to the north and south and along the MHHW line for adjacent upland areas. Contaminated sediment thickness at each of these boundaries was assumed to be zero in order to conduct the IDW interpolation. The thickness of sediment above the SQS is shown in Figures 8a and 8b.

Table 1
Thickness of Sediment Exceeding SQS

Core ID	Existing Mudline (feet MLLW)	Thickness of Contamination (feet)[1]	Clean Elevation (feet MLLW)[2]
EW10-SB01	-11.92	26.5 [3]	-38.4
EW10-SB02	-27.95	12.0	-40.0
EW10-SC03	-6.11	2.7	-8.8
EW10-SC04	1.21	5.4	-4.2
EW10-SC05	-10.85	1.9	-12.8
EW10-SC06	-29.24	6.8	-36.0
EW10-SC07B	-18.11	4.2	-22.3
EW10-SC08	-36.13	9.2	-45.3
EW10-SC09	-40.14	7.7	-47.8
EW10-SC10	-37.07	4.3	-41.3
EW10-SC100	-52.01	0.0	-52.0
EW10-SC101	-54.25	0.0	-54.3
EW10-SC11	-37.01	6.1	-43.1
EW10-SC12	-39.42	5.6	-45.0
EW10-SC13	-48.65	1.9	-50.5
EW10-SC14	-49.20	6.1	-55.3
EW10-SC15	-42.00	2.3	-44.3
EW10-SC16	-44.00	5.5	-49.5
EW10-SC17	-44.00	11.8	-55.8
EW10-SC18	-42.00	6.2	-48.2
EW10-SC19	-50.41	4.1	-54.5
EW10-SC20	-52.00	0.4	-52.4
EW10-SC21	-51.03	5.5	-56.6
EW10-SC22	-53.53	2.0	-55.5
EW10-SC23	-15.30	11.4	-26.7
EW10-SC24	-48.00	8.3	-56.3
EW10-SC25	-52.00	0.9	-52.9
EW10-SC26	-52.00	2.9	-54.9
EW10-SC27	-27.49	8.2	-35.7
EW10-SC28	-54.00	11.8	-65.8
EW10-SC29	-12.00	13.2	-25.2
EW10-SC30	-43.72	6.1	-49.8

Table 1
Thickness of Sediment Exceeding SQS

Core ID	Existing Mudline (feet MLLW)	Thickness of Contamination (feet)[1]	Clean Elevation (feet MLLW)[2]
EW10-SC31	-54.00	2.9	-56.9
EW10-SC32	-37.62	9.0	-46.6
EW10-SC33	-30.68	6.1	-36.7
EW10-SC34	-54.00	0.2	-54.2
EW10-SC35	-43.62	2.1	-45.7
EW10-SC36	-52.00	3.3	-55.3
EW10-SC37	-53.43	2.1	-55.5
EW10-SC38	-52.00	0.0	-52.0
EW10-SC39	-54.00	2.1	-56.1
EW10-SC40	-54.00	4.2	-58.2
EW10-SC41	-52.17	0.0	-52.2
EW10-SC42	-54.00	5.6	-59.6
EW10-SC43	-53.70	4.6	-58.3
EW10-SC44	-54.00	0.0	-54.0
EW10-SC45	-52.00	0.0	-52.0
EW10-SC46	-54.00	0.0	-54.0
EW10-SC47	-54.96	4.5	-59.5
EW10-SC48	-33.59	6.2	-39.8
EW10-SC49	-54.02	1.6	-55.6
EW10-SC50	-37.46	1.9	-39.4
EW10-SC51	-61.75	0.0	-61.7
EW10-SC52	-32.97	4.4	-37.4
EW10-SC53	-54.46	5.7	-60.1
EW10-SC54	-8.81	13.0	-21.8
EW10-SC55	-54.65	2.3	-56.9
EW10-SC56	-56.00	0.0	-56.0
EW10-SC57	-40.00	2.0	-42.0
EW10-SC58	-34.17	6.7	-40.8
EW10-SC59	-40.35	0.0	-40.4
EW10-SC60	-42.00	0.9	-42.9
EW10-SC61	-42.00	1.1	-43.1
EW10-SC62	-56.00	0.0	-56.0
EW10-SC63	-53.70	0.0	-53.7

Notes:
1 "Contaminated Thickness" is based on the top of the first sample interval with concentrations below Sediment Quality Standards (SQS), except for EW10-SC29, which was above SQS in the lowest interval.
2 "Clean Elevation" is the contaminated thickness (greater than SQS) subtracted from the existing mudline elevation.
3 EW10-SB01 was collected using a barge-mounted drill rig on the Mound Area within the EW.
MLLW – mean lower low water

2.6 Physical Conceptual Site Model

The preliminary Physical Processes CSM provided in the CSM Report (Anchor, Windward and Battelle 2008) is supported by the recently collected Sediment Transport Evaluation (STE) data. An overview of the preliminary Physical Processes CSM, as summarized in the Draft STER (Anchor QEA and Coast and Harbor 2011), is provided below. The SRI will present the physical CSM that will be used in the FS.

2.6.1 East Waterway Reaches

The EW is physically divided into three reaches, as originally defined in the CSM Report (Anchor, Windward and Battelle 2008) and shown in Figure 4. The first reach encompasses the main body of the EW between the Spokane Street corridor and the EW mouth that opens into Elliott Bay (Main Body Reach). The Main Body Reach is approximately 7,400 feet long. The second reach is under the bridges in the Spokane Street corridor (Sill Reach), which has rarely, if ever, been dredged. The Sill Reach is approximately 350 feet long. The third reach is south of the Spokane Street corridor and north of the junction with the WW and LDW (Junction Reach). The Junction Reach is approximately 500 feet long.

The hydrodynamics of the EW are governed largely by flows at the northern and southern boundaries; that is, at the open boundary with Elliott Bay to the north and at the junction with the WW and LDW to the south. The geometry of the EW at the sill is also important for EW hydrodynamics, because of the reduced cross-sectional area in the Sill and Junction Reaches. The Sill Reach serves to limit flows typical of estuarine systems, including underlying saltwater flows in the lower part of the water column below the surficial freshwater layers. The Sill Reach will limit flows between the Junction and Main Body Reaches because its width and cross-sectional area are smaller than in the adjacent two reaches. This limitation occurs when LDW flows are high, producing flows to the north through the Sill Reach. This limitation also occurs when LDW flows are low during tidal flooding, producing flows to the south.

2.6.2 East Waterway Hydrodynamics

Current velocities within the EW due to tidal and riverine currents are relatively low during periods of low upstream inflow. As upstream inflow increases, surface velocities within the EW increase. Surface velocities are highest in the Junction and Sill Reaches (maximum 90 centimeters per second [cm/s]), and are lower in the Main Body Reach (maximum 40 cm/s). Near-bed velocities are highest in the Main Body Reach near the mouth of the EW (maximum 18 cm/s) and lowest in the area south of Slip 27 (maximum 2 cm/s). The presence of distinct two-layer flow (inflow of higher density saline water at depth with outflow of fresher water at the surface) becomes more prevalent as upstream inflow increases. During low flow events, vertical gradients in salinity are consistent throughout the EW. During high flow events, vertical gradients in salinity are more pronounced in the Main Body Reach, where a layer of freshwater overlies high-salinity water. During high flow events in the Sill and Junction Reaches, freshwater may be present throughout the water column.

Freshwater input to the EW and WW from upstream sources is split equally during periods of lower flow (i.e., less than 2-year flood). During flood events greater than the 2-year flow, the EW:WW flow split is consistently about 30%:70% (from 2- to 100-year flows).

2.6.3 Erosion Potential

Based on Sedflume data summarized in the Draft STER (Anchor QEA and Coast and Harbor 2011), the maximum predicted bed shear stress for a 100-year high-flow event (0.12 Pascals [Pa]) is below the lower confidence bound value for critical shear stress (0.20 Pa). Therefore, it is not anticipated that significant bed scour or erosion of in situ bed sediments will occur anywhere in the EW as a result of tidal or riverine currents.

Near-bed velocities generated by episodes of propwash are confirmed to be significantly higher than those due to tidal and riverine currents in areas of the EW that are subjected to large vessel operations, which are most frequent north of Slip 27. Some large vessels can enter the part of the Main Body Reach south of Slip 27, but the majority of large vessel operations occur north of Slip 27. Consequently, bed shear stress due to vessel operations is significantly greater than bed shear stress due to natural forces in those areas. Erosion potential in the Main Body Reach of the EW due to propwash is anticipated to be more significant north of Slip 27 (EW Stations 0 to 4000) and within Slip 36 (compared to areas south of Slip 27 [EW Stations 4000 to 7600] and within Slip 27) due to concentrated container ship activity in those areas (Figure 4). Geochronology cores collected as part of the EW STE and surface sediment samples collected for sediment characterization were used to provide additional lines of evidence for comparison with propwash results. In general, results of the geochronology evaluation coincide with the results of the propwash evaluation. Cesium-137 (Cs-137) results from the geochronology core analysis (Figure 3-1 in the Draft STER [Anchor QEA and Coast and Harbor 2011]) suggest that areas within Slip 27 and just south of Slip 27 between EW Stations 4000 and 6200 are net depositional and have not been impacted by mixing events below the surface sediments (since Cs-137 peaks were documented for most of those cores). This area coincides with areas where maximum bed shear stress due to propwash (for existing conditions) is estimated at 2 Pa. Bed shear stress values of 2 Pa may be large enough to disturb surface sediments, but are less likely to disturb sediments below the surface (e.g., top 10 cm). Localized disturbance to sediments deeper than 10 cm could occur within Slip 27 and south of Slip 27 (e.g., as a result of extreme propwash forces associated with emergency maneuvering). The single geochronology data point in Slip 27 does not indicate mixing below the top 10 cm. Therefore, the data may suggest that not all areas within Slip 27 will be affected by propwash.

The area north of Slip 27 (EW Stations 0 to 4000, where Cs-137 peaks were not found in tested cores) appears to be impacted by vertical mixing of both surface and subsurface sediments. This area coincides with areas where maximum bed shear stress due to propwash is estimated at 9 to 23 Pa.

2.6.4 Net Sedimentation in the East Waterway

An evaluation of 18 geochronology cores suggests that portions of the EW north of Station 6200 and south of Slip 27, as well as the interior of Slip 27 are net depositional with minimal mixing of sediments in these areas. Areas north of Slip 27 (including at the mouth of Slip 36) are likely net depositional, but appear to be heavily influenced by episodic erosion events, as radiochemistry results for cores located in those areas indicate the presence of a well-mixed sediment bed. No geochronology cores were collected within the interior of Slip 36.

Although areas between Stations 6200 and 6800 (north of the bridges), as well as the interior of Slip 27, appear to be net depositional, grain size distribution data for those cores show that surface sediments in those areas are significantly coarser than in the deeper areas of the Main Body Reach, which suggests that finer grain size material (clays and silts) may not be depositing in these areas or is being actively resuspended.

Some geochronology cores were not retrieved in the Sill and Junction Reaches due to consolidated gravel surface sediments in those areas. This suggests that these areas are likely not net depositional due to relatively high tidal and riverine currents and coarse-grained material present in this portion of the EW. Estimates of bottom shear stress due to tidal and riverine currents in these areas are all below the critical shear stress value estimated for bed sediments in the EW (from Sedflume cores) and, therefore, sediments in this area are not likely to resuspend. Propwash results in the Junction Reach predict bottom shear stress due to vessel operations in that area to be higher than the value of critical shear stress for bed sediments, resulting in potential resuspension. However, no Sedflume cores were retrieved in the Junction Reach due to consolidated bed sediments; therefore, there is uncertainty in the estimate of critical shear stress for bed sediments in this area.

2.6.5 Contribution of Solids from Lateral Sources

Preliminary particle tracking model (PTM) results (as discussed in the Draft STER [Anchor QEA and Coast and Harbor 2011]), which predict sediment mass accumulation within the EW from lateral sources based on hydrodynamic forces, is greatest close to the outfall locations. The contribution of solids from lateral sources declines quickly with increasing distance from the outfall location with relatively little deposition occurring in much of the deeper areas of the Main Body Reach. Because PTM does not consider the redistribution of these particles from propwash forces or currents, some solids from lateral sources could be resuspended and distributed beyond the locations predicted by PTM. The PTM results, therefore, correspond to the initial deposition in the absence of any resuspension from propwash forces or currents. Contributions from lateral sources are related to the evaluation of recontamination potential and long-term effectiveness of any remedy. Detailed evaluations of contaminant sources are not included in this Screening Memo, but will be evaluated in the FS as part of recontamination potential.

2.7 Key Site-Specific Assumptions

Based on characteristics described in this section, a number of EW-wide key assumptions have been developed for this Screening Memo, as listed below:

- **Physical Structures**: There are extensive structures present throughout the EW, each with specific structural limitations with respect to remediation. Implementation of dredging or capping alternatives in these areas is reviewed in Section 4 for each technology. Those remedial technologies that are screened out due to specific implementability, effectiveness, or cost issues are discussed in detail. However, less detail is included for those technologies that are retained for further consideration. Development of site-specific, localized approaches for specific areas with physical limitations will be developed at a conceptual level in the FS. For the purposes of costing in this Screening Memo, different unit costs have been developed for readily accessible open-water areas and for underpier areas.
- **Bathymetry:** Different types of dredging or excavation equipment will be appropriate, as determined by the bathymetry and other physical site features. For the purposes of cost and feasibility analyses in this Screening Memo, it is assumed that removal actions for accessible areas (e.g., without overwater structures) can all be accomplished with conventional dredging equipment.
- **Required Navigation and Berthing Elevations**: At locations where remediation is required in the federal navigation channel and/or facility berthing areas, remediation will need to be conducted to maintain the authorized/required elevations. Recent USACE guidance for maintaining a buffer between remedial actions and the federal navigation channel may apply to the EW (USACE 2010).
- **Contaminants of Concern**: COCs include contaminants with detected exceedances of SMS criteria for the purposes of identifying surface areas that require remediation. These COCs have been used to establish contaminated sediment volume required to be removed under the dredging alternatives. Other COCs will be evaluated spatially and vertically to determine if additional remediation is necessary in the FS.

- **Spatial Extent of Contamination:** Areas with surface sediment contaminant concentrations exceeding SQS standards are used to develop remedial action alternatives (Figure 6). SMS designations were developed for each sample location and associated Thiessen polygon based only on chemistry concentrations, and do not consider the results of toxicity testing. Although the results of the toxicity testing are important from an ecological risk perspective, some samples that contain elevated contaminant concentrations above SMS but with toxicity testing results below SMS may still contribute to elevated human health risk. To ensure a simplified and uniform approach for evaluation of all remedial alternatives, only chemistry results will be used for this evaluation.
- **Vertical Depth of Contaminated Sediment**: For the purpose of evaluating sediment volumes in areas requiring remediation and the associated conceptual-level costs in this Screening Memo, the vertical depth of contaminated sediments is based on the volume estimates developed using the thickness of sediment exceeding SQS criteria (as described in Section 2.3). For the Screening Memo, a design factor has been applied to these volumes to account for additional volume removed following dredge prism design (factor of 1.5, or 50% increase in contaminated sediment volume). The additional volume responsible for this design factor includes allowable overdredge thickness, an allowance to account for additional sediment characterization during design, an allowance to account for cleanup passes for residuals management, and additional volumes required for constructability of dredge prisms, such as stable side slopes (Palermo 2009). The FS will develop detailed volume estimates using RALs for retained remedial alternatives and will take into consideration dredge prism design and allowable overdepth.
- **Sediment Stability:** Areas in the EW south of Slip 27, within the interior of Slip 27, and in portions of the EW north of Station 6200 are believed to be depositional (based on the Draft STER [Anchor QEA and Coast and Harbor 2011]), suggesting the potential for natural recovery. While localized disturbance of sediments could result from propwash forces, geochronology results still indicate a net depositional environment. Other areas are likely not to be depositional because they are subject to relatively high tidal and riverine currents (in the Sill and Junction Reaches) or significantly mixed due to vessel movement (north of Slip 27).

- **Recontamination and Natural Recovery Potential**: Recontamination or natural recovery of the site following remediation as a result of upstream and lateral inputs has not been considered for this Screening Memo. The contribution of sediments with elevated concentrations and resulting potential to recontamination will be considered as part of development and evaluation of remedial alternatives in the FS. The FS will also include a detailed analysis of natural recovery processes to evaluate alternatives that include monitored natural recovery (MNR) and enhanced natural recovery (ENR) as remedial technologies. The FS will also provide estimates of post-cleanup surface-weighted average concentration (SWAC) reductions that will be expected to occur over time throughout the EW as a result of the ongoing natural recovery processes.

3 PRELIMINARY REMEDIAL ACTION OBJECTIVES

This section describes the development of preliminary RAOs for the EW. RAOs are narrative statements describing the goals for future remedial actions and serving as the design basis for the remedial alternatives to be developed in the FS (EPA 1999). EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988) specifies that RAOs are to be developed based on the results of the HHRA and ERA because RAOs consist of medium- and/or OU-specific goals for protecting human health and the environment. Development of preliminary RAOs in this Screening Memo is based on the Draft Baseline HHRA (Windward 2011c) and Draft Baseline ERA (Windward 2011a). At the end of the SRI/FS process, the selected remedial alternative or combination of alternatives should achieve the RAOs.

Preliminary RAOs are developed early in the RI/FS process as statements of narrative goals for the site. They provide the foundation upon which numeric PRGs, cleanup levels, and remedial alternatives can be developed. PRGs and RALs to achieve protection of human health and ecological receptors will be further developed in the FS.

The preliminary RAOs developed in this Screening Memo address the primary exposure pathways, receptors, and COCs, based on the current understanding of the EW OU. Preliminary RAOs will be revised in the RAO Memorandum, which will be submitted to EPA following finalization of the risk assessments, and contain the following elements:

- Applicable or relevant and appropriate requirements (ARARs) and other standards or criteria to be considered
- Key findings of risk assessments
- Revised narrative RAOs
- Approach for developing PRGs for the RAOs

It is anticipated that the final RAOs will continue to be broadly defined statements of goals for the overall remediation, but that these final statements may be refinements of the preliminary RAOs proposed in this Screening Memo.

The Preliminary RAOs for the SRI/FS are summarized below. These RAOs are consistent with the LDW FS (AECOM 2010), where appropriate.

The Preliminary RAOs are listed below:

- **RAO 1:** Reduce human health risks associated with the consumption of resident EW fish and shellfish by reducing sediment and surface water concentrations of COCs to protective levels.[1]
- **RAO 2:** Reduce human health risks associated with exposure to COCs through direct contact with sediments and incidental sediment ingestion by reducing sediment concentrations of COCs to protective levels.
- **RAO 3:** Reduce risks to benthic invertebrates by reducing sediment concentrations of COCs to comply with the Washington State SMS and to protective levels for non-SMS COCs.
- **RAO 4:** Reduce risks to crabs, fish, birds, and mammals from exposure to COCs by reducing concentrations of COCs in sediment and surface water to protective levels.[2]

These preliminary RAOs follow EPA guidance (EPA 1988) and may be refined as the project moves forward during the SRI/FS process.

3.1 Preliminary Remediation Goals

PRGs are numeric concentrations of risk drivers (i.e., indicator hazardous substances) in environmental media associated with each RAO. The process for developing PRGs will be described in the RAO Memorandum following finalization of the baseline risk assessments. Numeric PRGs will not be included in the RAO Memorandum because the development of risk-based threshold concentrations (RBTCs), or sediment concentrations of risk driver chemicals that are associated with specific risks, will not be completed until the SRI. Therefore, the PRGs will be presented in the FS and will be developed in parallel to any modification of the preliminary RAOs presented in this Screening Memo.

[1] Expected improvements to surface water quality will be achieved through remediation of site sediments; no active remediation of surface water will be considered.

PRGs must comply with chemical specific ARARs (EPA 1991) and are designed to provide adequate protection of human health and the environment through the protection of specific exposure pathways or receptors (EPA 1997). PRGs are based on preliminary site information and will be presented as sediment concentrations for the risk drivers, established based on the following factors:

- ARARs including SMS criteria
- RBTCs based on information presented in human health and ecological risk assessments
- Background concentrations if protective RBTCs are below background concentrations
- Practical quantitation limits (PQLs) if protective RBTCs are lower than PQLs. PQLs are the lowest concentration that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions.

PRGs for each risk driver are expected to be the more stringent value of the ARARs and RBTCs, but not below the background concentration or the PQL. PRGs will be used in the FS to establish RALs, which will be used to identify the types, locations, areas, and volumes of sediment that require remediation. At the end of the SRI/FS process, cleanup levels will be established by EPA based on the refined PRGs, RALs, and the results of the detailed evaluation of remedial alternatives. Cleanup goals will be finalized by EPA and presented in the ROD.

4 IDENTIFICATION AND SCREENING OF REMEDIAL AND DISPOSAL TECHNOLOGIES

This section identifies and describes the candidate remedial and disposal technologies that may be applicable to the EW OU. It includes a preliminary list of processes and equipment associated with each candidate remedial and disposal technology that could be incorporated into development of remedial alternatives based on the physical conditions and COCs within EW sediments. This section consists of the following components:

- A description of terminology, including General Response Actions (GRAs), remedial and disposal technologies, and process options (listed in Table 2)
- A description of evaluation criteria used to evaluate remedial and disposal technologies and remedial alternatives (Section 4.1)
- A description of critical site restrictions in the EW, which can affect the implementability of certain technologies (Section 4.2)
- A description of each remedial technology (Section 4.3)
- A description of each disposal technology (Section 4.4)
- A summary of retained remedial and disposal technologies (Section 4.5)

Evaluation of GRAs, remedial and disposal technologies, and process options are key components to be considered as part of development of remedial alternatives for cleanup of EW sediments, and are defined below:

- **General Response Actions** – Major categories of cleanup activities that could be applied to manage COCs in sediments. GRAs include no action, natural recovery, institutional controls, containment, removal, treatment, and disposal. GRAs for the EW OU apply to sediment and may be used singly or in combination to satisfy the RAOs developed for the site.
- **Remedial and Disposal Technologies** – General categories of technologies within a GRA that describe a means for achieving the RAOs. For example, removal is a GRA that can be achieved using in the dry excavation or dredging technologies, while treatment is a GRA that can be achieved using physical, biological, or chemical technologies. Innovative technologies will also be evaluated, as required per EPA guidance (EPA 1988).

- **Process Options** – Specific processes within each technology type. Process options are selected based on the characteristics of the medium (e.g., sediment), site conditions, and the availability of technologies to address the medium or site conditions. For this Screening Memo, a range of process options are identified to illustrate the variety of process options that could be implemented during remedial construction. At this conceptual-level screening phase, unless otherwise noted, eliminating certain process options may inadvertently limit potential remedial technologies from consideration in the FS and/or Remedial Design phase. Therefore, this Screening Memo primarily focuses its screening at the remedial and disposal technologies level, with some detailed discussion on process options where it is important to note critical factors with specific process options. Some process options are identified and screened out in this Screening Memo where critical factors make the process option infeasible.

Following CERCLA guidance, cleanup technologies are organized under GRAs that represent different conceptual approaches to remediation. These general response actions include the following:

- No Action
- Institutional Controls
- MNR
- ENR
- In situ Containment
- Removal Technologies
- In situ Treatment
- Ex situ Treatment
- Disposal Technologies

Table 2 describes the GRAs, technology types, and process options potentially appropriate to the EW OU sediments. Each of the elements identified are discussed in subsequent sections of this Screening Memo. Remedial technologies are described in Section 4.3, and disposal technologies are described in Section 4.4. The technologies discussed include information that has been reviewed as part of the *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005), as well as the *Lockheed West Seattle Superfund Site Final Screening of Remedial Technologies and Assembly of*

Preliminary Alternatives (Tetra Tech 2010). These documents have been reviewed by stakeholders and approved by EPA, and are relevant to the EW based on proximity of the sites to each other, similar site conditions, and similar COCs. This section expands upon the evaluation conducted for the LDW and Lockheed West Seattle in those reports based on information specific to the EW.

Table 2
Identification of General Response Actions, Technology Types, and Process Options Potentially Appropriate for the East Waterway SRI/FS

GRA	Technology Type	Process Option	Section
No Action	None	Required by National Contingency Plan	Section 4.3.1
Institutional Controls	Administrative and legal controls	Waterway use restrictions and maintenance agreements	Section 4.3.2
		Access and property use restrictions	
		Informational devices (e.g., signage and fish consumption advisories)	
Natural Recovery	Monitored Natural Recovery	Sedimentation	Section 4.3.3
	Enhanced Natural Recovery	Placement of thin layer of clean cover	Section 4.3.4
In situ Containment	Cap	Conventional Cap	Section 4.3.5
		Low-permeability Cap	Section 4.3.5
Removal	Dry Excavation	Excavator	Section 4.3.6.1
	Dredging	Mechanical Dredging	Section 4.3.6.2
		Hydraulic Dredging	
		Underpier Dredging	
In situ Treatment	Physical-Immobilization	Granulated Activated Carbon	Section 4.3.7.1
		Stabilization	
		Electro-chemical Oxidation	
		Vitrification	
		Ground Freezing	
	Biological	Slurry Biodegradation	
		Aerobic Biodegradation	
		Anaerobic Biodegradation	
		Imbiber Beads	
	Chemical	Slurry Oxidation	
		Oxidation	

Table 2
Identification of General Response Actions, Technology Types, and Process Options Potentially Appropriate for the East Waterway SRI/FS

GRA	Technology Type	Process Option	Section
	Physical-Extractive Processes	Oxidation	
		Sediment Flushing	
Ex situ Treatment	Physical/Chemical	Acid Extraction	Section 4.3.7.2
		Solvent Extraction	
		Slurry Oxidation	
		Reduction/Oxidation	
		Dehalogenation	
		Sediment Washing	
		Radiolytic Detoxification	
	Biological	Enhanced Bioremediation	
		Slurry-phase Biological Treatment	
		Fungal Biodegradation	
		Landfarming/Composting	
		Biopiles	
	Physical	Separation	
		Solar Detoxification	
		Solidification	
	Thermal	Incineration	
		High-temperature Thermal Desorption (HTTD)	
		Low-temperature Thermal Desorption (LTTD)	
		Pryolysis	
		Vitrification	
		High-pressure Oxidation	
Disposal/Reuse	On-site disposal	Confined Aquatic Disposal (CAD)	Section 4.4.1
		Slip 27 Nearshore Confined Disposal Facility (NCDF)	
		Slip 36 NCDF	
	Off-site Disposal	T5 NCDF	Sections 4.4.2 and 4.4.3
		Landfill	
		Open-water Disposal	
		Beneficial Use	

The identification and screening of remedial technologies and process options generally follows EPA's Guidance for Conducting RI/FSs (EPA 1988, 2005). This evaluation ensures that only those technologies and process options applicable to the contaminants present, their physical matrix, and other site characteristics will be considered and carried forward into the assembly of alternatives. The screening in this section will be based primarily on a technology's ability to effectively address the contaminants at the site, but will also consider a technology's implementability and cost. After the identification and screening steps are completed in this section, the retained technologies (and representative process options) are assembled into a focused set of site-wide alternatives in accordance with CERCLA guidance in Section 5. Retained remedial alternatives from Section 5 will be further expanded upon in the FS to develop a greater range of remedial alternatives that fall within the same category of retained alternatives from this Screening Memo. Technologies eliminated as part of this Screening Memo may be re-introduced during the FS or remedial design if conditions change or new information becomes available, as determined appropriate by EPA.

4.1 Evaluation Criteria

For the purposes of this Screening Memo, remedial technologies and remedial alternatives (Section 5) are evaluated and screened on the basis of implementability, effectiveness, and cost. These three criteria represent a short list of key CERCLA evaluation criteria, and are discussed in more detail below.

4.1.1 Implementability

The implementability criterion evaluates the technology for technical and administrative feasibility and availability of services and materials. Technical feasibility refers to the ability to construct, operate, maintain, and monitor the action during and after construction and meet technology-specific regulations during construction. A key technical feasibility factor includes assessing technologies against critical site restrictions (i.e., structural restrictions and use, and habitat and water depth considerations). Because the EW is highly developed and contains significant critical site restrictions, the screening evaluation for implementability will discuss a technology's ability to work within the critical site restrictions. Administrative feasibility refers to the ability to obtain permits for off-site actions (on-site actions would be performed under CERCLA authority) and the availability of specific equipment and technical specialists. Availability of services and materials includes the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists; and availability of prospective technologies. Implementability is generally ranked as low, moderate, and high; ranging from difficult implementation (low ranking) to easy implementation (high ranking).

4.1.2 Effectiveness

The effectiveness criterion for remedial and disposal technologies qualitatively considers: 1) the potential capability of technology options in handling the estimated volumes of sediments; 2) potential impacts to human health and the environment during the construction and implementation phase; and 3) how proven and reliable the technology/process is given the contamination and conditions of EW sediments and the site. Effectiveness for remedial or disposal technologies is generally ranked as low, moderate, and high. Low ranking implies inability or limited ability in achieving the above three factors; high ranking implies that the remedial or disposal technology is a proven method for achieving the above three factors.

For this Screening Memo, the effectiveness criterion for remedial alternatives (Section 5) evaluates the remedial alternative's ability to achieve the surrogate RALs and to protect human health and the environment, both in the short-term and long-term. Short-term effectiveness addresses how a remedial alternative impacts its surroundings during the construction and implementation phase(s) of the remedial action. Long-term effectiveness refers to the period after remedial action has been completed. Effectiveness is generally ranked as low, moderate, and high. Low ranking implies overall inability or limited effectiveness of the remedial alternative to achieve the surrogate RALs and protect human health and the environment in the short- and long-term; high ranking implies that the remedial alternative is a proven method overall for achieving RAOs and protecting human health and the environment in the short- and long-term.

4.1.3 Cost

The cost criterion is used to relatively assess different technologies or alternatives. The relative costs of a given technology are not quantitatively estimated as part of the remedial technology screening; however, knowledge of typical technology costs obtained from vendors, cost-estimating guides, prior projects, and engineering judgment are used to determine the relative cost of a technology compared with other similar technologies. For each remedial alternative in this Screening Memo, an order-of-magnitude cost has been developed for remedial construction only without including construction contingencies, but will not include most of the typical non-construction costs (e.g., engineering design, permitting, and long-term operations and maintenance); non-construction costs can make up a significant portion of the remedial alternatives' total project costs. Relative costs will not be used to screen out a potential remedial technology or alternative, but costs will be considered in combination with the other screening criteria. Cost is generally ranked as low, moderate, and high, and reflects the cost relative to other technologies or alternatives.

4.2 Critical Site Restrictions for the East Waterway

The EW is an industrial waterway with structures (e.g., pile-supported piers, bridges, and riprap slopes) located in nearly all shoreline areas. Many of the areas under and adjacent to these structures restrict the technical and economic feasibility to implement specific technologies and process options. Specific factors that may restrict the implementability include site access (e.g., feasibility of using upland facilities, USCG moorage of vessels within Pier 36); physical obstructions and structural conditions such as piers, bridge structures, or partially demolished aquatic structures; water depths (i.e., site bathymetric conditions); and navigation and other site use considerations. Based on these factors, the EW has been divided into specific Construction Management Areas (CMAs) that represent areas with similar structural conditions, or similar aquatic use, habitat, or water depth conditions. These CMAs are shown on Figure 9 and defined in Table 3.

Structural restrictions and use, habitat, and water depth considerations associated with various areas of the EW are described in Sections 4.2.1 and 4.2.2, respectively, and shown on Figure 10. Figures 11 and 12 show typical underpier cross sections for T-18 and T-30, respectively, which identify key structural elements described in Section 4.2.1.

4.2.1 Structural Restrictions

There are structural restrictions in the EW that may limit the use of specific remedial technologies due to limited site access or potential for adverse impacts to structural or slope stability. The proximity to these structures may limit the ability to implement certain remedial technologies or process options. Detailed information on adjacent facilities and infrastructure is found in the EISR (Anchor and Windward 2008). A summary of these structural restrictions and/or assumptions developed in the absence of detailed structural information are provided in Table 3 and shown on Figure 10.

4.2.2 Use, Habitat, and Water Depth Considerations

Use, habitat, and water depth considerations in the EW could potentially limit the range of remedial technologies that could be considered for specific CMAs. These considerations are detailed in Table 3 and shown on Figures 10, 11, and 12.

Table 3
Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Junction Reach	Located south of the Spokane Street corridor and north of the junction with the LDW. Both west and east sides of the EW in this area contain riprap slopes, with floats for small vessels along the west side of the waterway.	Piling and small vessel floats are present in the waterway, but present minimal structural restrictions in this area. It is assumed that dredging adjacent to the piling should be minimized and dredging at the base of slopes should consider overall slope stability. Existing riprap slopes may limit the ability to conduct remediation immediately adjacent to the riprap slopes without slope improvements.	A shallow bench along the eastern shoreline at T-104 was constructed of fine-grained substrate and provides valuable shallow water habitat for juvenile migratory fish, and intertidal areas provide clam habitat. The site may require mitigation if affected by cleanup. Small draft recreational and commercial boats move in and out of the Harbor Island Marina (T-102) from the LDW. Tribal netfishing may occur within this area.
Sill Reach	Located under the bridges in the Spokane Street corridor. Four bridge structures pass through this area, including the Spokane Street Bridge and Service Road Bridge between T-102 and T-104, West Seattle Bridge, and BNSF Railway (Railroad Bridge). Elevations in this area range from -4 to -11 feet MLLW.	The West Seattle bridge columns located in the water on each side of the EW are supported by a pile-supported footing or pile cap (approximately 26 feet by 32 feet each) with top of footing at approximately -7 feet MLLW. Similar sized pile caps for columns exist upland on each side of EW. Additional area adjacent to these columns may have seen some soil improvements that provide additional structural stability to the column and should be considered if significant soil were to be removed. The existing bridge structures limit access for equipment and may restrict removal and/or containment remedial actions underneath the bridges, or immediately adjacent to the bridge structures. The bridge structures are considered critical infrastructure.	Clam habitat is present in intertidal areas. Habitat restoration is proposed for the west side of the EW under the West Seattle Bridge, which would provide off-channel mudflat and marsh habitat, along with riparian vegetation. The project would also involve removal of debris and creosote structures from the shoreline areas. The restoration is subject to Natural Resource Damage Trustee approval and EPA coordination. Construction could occur as early as 2012.

Table 3

Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Shallow Main Body – Stations 6200 to 6850	Located north of the Sill Reach before the EW widens to its full 750 feet width. This area is used to moor tugs and barges along the western side, where a concrete bulkhead is present. There is also a wooden wharf pile-supported structure in-line and to the south of the concrete bulkhead. Details on the date and type of original construction of these structures are unknown.	Design and construction details of the concrete bulkhead and timber wharf structure on the west side of the EW are unknown. However, the condition of the concrete structure is relatively poor, based on visual observation. Dredging adjacent to the bulkhead may cause structural impacts.	Numerous barges and tugboats are moored along the west side of the EW. This area also contains a mound of rock placed in the southeast portion of this area specifically for habitat restoration purposes. The mound provides shallow water habitat just north of the Spokane Street pedestrian bridge. Tribal netfishing occurs within this area.
Former Pier 24 Piling Field	A timber bulkhead and timber piles are present along the southern shoreline of Pier 24. Removal is planned for these piles, a small pier, and in-water debris, which currently occupy approximately 2.1 acres of aquatic and shoreline area, for fish and wildlife habitat improvements. The top of the existing bulkhead is lower than high tides. No timetable for this work is currently established.	Removal of piling would be required prior to implementation of remedial alternatives in this area. Structural condition of the existing bulkhead wall is severely deteriorated. As such, removal of the pile and/or any dredging in this area will require strengthening of this wall or removal of the wall plus associated upland grading to contour in-water and upland slope to final desired grades.	This area is targeted for habitat restoration, and restoration potentially could be implemented in combination with whatever remedial action is selected for this area.
Shallow Main Body – Stations 5700 to 6200	Located north of where the EW widens to its full 750 feet, and south of the Federal Navigation Channel. This area extends approximately from Station 5750 to Station 6150.	No structural restrictions	The water depths in this area reach a maximum depth of -43 feet MLLW (except for the berthing area at T-25, which was designed for -50 feet MLLW). Some limited vessel navigation occurs in this area. Tribal netfishing occurs within this area.

Table 3

Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Underpier Areas	Underpier areas apply to T-18, T-25, Slip 27, T-30, Pier 36/37, and T-46 and extend from approximately 125 feet shoreward of the Pier Head Line.	Due to very limited access to underpier areas, only from the water, it is considered extremely difficult to remove sediments from the underpier slopes. Specialized dredging equipment may be capable of removing some of the underpier sediment, but likely not 100% of all sediment. Any underpier removal work would likely need to be conducted using diver assisted methods, and the risks for injury and death during construction will need to be weighed against long-term risk of leaving contaminated sediment underpier. Capping or placement of ENR materials within the underpier areas may be infeasible due to equipment access and placement issues. Also, the underpier slopes are typically too steep to place a stable cap over them, plus potential drawdown effect on piling from placing material on the slopes may cause structural damage.	Underpier areas provide habitat for rockfish and epibenthic food for salmon.

Table 3
Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Berth Areas (T-18, T-25, T-30)	Berth areas extend along T-18, T-25, and T-30 and are approximately 150 feet wide, between the Federal Navigation Channel and the Pier Head Line.	Berth areas within the EW are actively used by a variety of vessels, the largest of which are container ships. Required berthing elevations typically match the Federal Navigation Channel's authorized elevation of -51 feet MLLW. Removal in front of these terminals may need to limit dredging depths to avoid adversely impacting the existing pile-supported wharves. At **T-18, Berths 3 through 5**, a sheetpile wall (AZ48) was installed to provide slope stability to allow dredging along the toe of slope in Berths 3 through 5 between approximate Stations 4950 and 1900 (terminating at Communication Cable Crossing at bent 213). The capacity of the existing sheetpile wall limits any significant additional material removal at the toe of slope. For **Berth 6 at T-18** (south of Station 4950), no sheetpile wall is constructed, but it is assumed that a similar wall would be required to accomplish any significant dredging in this area. **T-25** has not had any significant structural berth deepening performed since initial construction in the 1970s. As such, it is unlikely that the structure can accommodate dredging below the initial design dredge elevation. Recent improvements at **T-30** (accomplished by the Port in 2007) were completed to allow for dredging in the berth area to -50 feet MLLW.	Along T-18, berthing area elevations are -51 feet MLLW from Station 0 to 4950. Berth 6 (south of Station 4950) depths at T-18 are approximately -35 to -40 feet MLLW. Along T-25, berthing area elevations are -50 ft MLLW. Along T-30, berthing area elevations are -50 feet MLLW. Tribal netfishing occurs within this area.

Table 3

Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Slip 27 Channel/ Pier 28	Slip 27 is located on the east side of the EW, between T-25 and T-30. It is 850 feet long and 240 feet wide. Pier 28 is the concrete structure located on the north side of Slip 27.	A 34-foot-wide truck bridge is present in the eastern portion of Slip 27 connecting T-25 and T-30. This bridge is located to the west of a structural bulkhead wall. The wall and bridge will likely limit the maximum depth of dredging in this area. **Pier 28** is a concrete deck and concrete pile structure that is considered at or near the end of its useful life. Structural observations of this facility in 2001 indicate that the pier is deteriorated. As such, it is not anticipated that significant dredging can occur in the berth area adjacent to this structure without structural improvements or removal.	Within Slip 27, miscellaneous vessels berth in Slip 27. Pier 28, at the northern portion of the slip, is currently used to berth various vessel and barges. The Slip 27 and Pier 28 areas are used by juvenile salmon. Tribal netfishing occurs within this area.
Slip 36/ T-46 Offshore	Slip 36 is located on the east side of the EW, between Pier 36 and Pier 37. It is approximately 1,200 feet long and 300 feet wide.	Recent construction work on **Pier 36 and within Slip 36** included dredging the berth areas. Further soil removal may not be possible without structural impacts. Recent dredge work at Terminal **46** determined that a non-structural maintenance dredge was possible to allow a berth depth of -51 feet MLLW. Further deepening of the berth area along the west face of the **Pier 46** apron would likely require associated structural improvements.	USCG vessels frequent Slip 36, which serves Pier 36 (south) and Pier 37 (north). The western half was dredged to -40 feet MLLW in 2005. USCG berths numerous vessels in Slip 36, including USCG Icebreakers, Cutters (greater than 65 feet in length), and gunboats.

Table 3
Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Mound Area/ Slip 27 Shoreline	This area is located on the east side of the EW just south of the mouth of Slip 27 and along the southern and eastern shoreline of Slip 27. It is open slope, typically with a riprap face.	No significant structural considerations; however, it is possible that structural walls could be necessary to accomplish significant removal of material along this slope without impacting the slope and/or yard area above.	The upland areas along the southern part of Slip 27 have been replanted in an effort to restore natural habitat conditions to this area. The restoration extends from the top of bank (18.5 feet MLLW) down to 12 feet MLLW. The shallow water and intertidal areas also provide habitat for clams and juvenile salmon. Tribal netfishing occurs within this area.
T-30/ USCG Nearshore	This area is located on the east side of the EW, between Slip 27 and Slip 36.	This area includes several severely deteriorated structures including remnant piers and both sheet pile and rock bulkhead walls. The specific structural condition of all structures is unknown but appears to be severely deteriorated suggesting that additional dredging and slope modifications would be problematic without associated structural improvements.	Jack Perry Park is a 1.1-acre park located north of T-30 and south of the USCG facility. It was constructed as mitigation for a street vacation, and provides 120 feet of intertidal area and shoreline access for public recreational activities. Smaller vessels, such as tugboats, barges, and Tribal fishing vessels navigate in this nearshore area. Future development along the shoreline of T-30 is possible, which could result in water depth requirements of -50 feet MLLW (the same as the current T-30 berth area water depth requirements). Tribal netfishing occurs within this area.

Table 3

Construction Management Areas in the East Waterway

Construction Management Area	Description	Structural Restrictions	Use, Habitat, and Water Depth Considerations
Communication Cable Crossing	A communications cable crosses the EW between T-18 and the northern portion of T-30 (Figure 4). This cable was originally buried between -61 and -66 feet MLLW in 1972 in an armored trench. As mentioned in Section 2.2.1, the location shown on Figure 4 changed following repair due to a vessel anchor incident at T-18. During the T-18 North Apron Upgrade in 2006, the existing crossing at the T-18 face of bullrail was located between bents 213 and 214 (Station 1850). On the T-30 side, the approximate crossing location is indicated by a visible marker on the shore (Station 1550).	For the purposes of this Screening Memo, it is assumed that the depth of sediment removal may be limited by the presence of the cable crossing .	Water depths in the footprint of the cable crossing range from -53 feet MLLW to -59 feet MLLW in the federal channel and berth areas. Tribal netfishing occurs within this area.
Federal Navigation Channel	The Federal Navigation Channel is 450 feet wide and extends from Station 0 to Station 5750. It is authorized to -51 feet MLLW.	No structural restrictions	The authorized channel elevation of -51 feet MLLW is required to support movement of large container vessels throughout the EW. Most vessel traffic consists of shipping companies moving container vessels and assorted tugboats into and out of the EW. Each container ship requires at least one tugboat to maneuver the ship during docking and undocking. Container ships call at T-18, T-25, and T-30. Other vessels, such as tugboats, barges, and USCG vessels, regularly use the navigation channel. Also note the Communication Cable Crossing described later in this table. Tribal netfishing occurs within this area.

4.3 Remedial Technologies

The identification and screening evaluation of potentially applicable remedial and disposal technologies are provided in the sections below.

4.3.1 No Action

No Action is a retained technology by default, as required per CERCLA. No Action will be used as a baseline comparison against other technologies. No Action requires no human intervention but can include long-term monitoring to ensure there are no long-term unacceptable risks to the environment or human health (EPA 1988); No Action can only be selected where the site poses no unacceptable risks to human health or the environment.

4.3.1.1 Implementability

The No Action technology is technically and administratively implementable in all CMAs and, therefore, ranks high for implementability.

4.3.1.2 Effectiveness

No Action must be retained, but this technology is not considered to be a proven and reliable technology at achieving the surrogate RALs and protecting human health and the environment for the EW. Overall, this technology is considered to have a low ranking for effectiveness.

4.3.1.3 Cost

Costs are expected to be low, and are primarily related to administrative and legal costs, as well as assumed general site-wide long-term monitoring costs. However, these costs are significantly lower than active remediation costs.

4.3.1.4 Summary

No Action is retained as a remedial technology as required per CERCLA (Table 4).

Table 4
Summary of Screening of No Action

GRA	Technology Type	Process Options	Implementability	Effectiveness	Cost	Screening Decision
No Action	NA	NA	High	Low	Low	Retained

4.3.2 Institutional Controls

Institutional controls are non-engineered instruments, such as administrative and legal controls, that may be included as part of a response action to minimize the potential for human health exposure to sediment contamination and ensure the long-term integrity of the remedy. CERCLA guidance prohibits the use of institutional controls as the primary mechanism for achieving RAOs unless active remedial measures, such as removal or containment, are not feasible. The two major types of institutional controls considered are proprietary controls and informational devices.

Proprietary controls may include:

- Waterway use restrictions and maintenance agreements
- Access and property use restrictions

Informational devices may include:

- Monitoring and notification of waterway users
- Seafood consumption advisories, public outreach, and education
- Enforcement tools
- Site registry

4.3.2.1 Implementability

Institutional controls are technically implementable, though administrative implementability of institutional controls would need to be coordinated with stakeholder groups, such as Tribes and regulatory agencies, as well as commitment from the public, site users, and site owners. Any use restrictions on state-owned aquatic land would require a use authorization from DNR. When using institutional controls alone, implementability is considered to have a moderate rank.

4.3.2.2 Effectiveness

Institutional controls alone are not considered to be a proven and reliable technology at achieving the surrogate RALs and protecting human health and the environment for the EW. Institutional controls are most often used in conjunction with remedial technologies that isolate or leave contaminated sediments in place or in circumstances where concentrations of contaminants in fish or shellfish are expected to post risks to human health for some time in the future (EPA 1997). However, such actions do not reduce the toxicity, mobility, or volume of contaminants. Therefore, when using institutional controls alone, effectiveness is considered to have a low ranking.

4.3.2.3 Cost

Costs are expected to be low, and are primarily related to administrative and legal costs, as well as potential long-term monitoring costs.

4.3.2.4 Summary

Institutional controls are retained as a remedial technology (Table 5).

Table 5
Summary of Screening of Institutional Controls

GRA	Technology Type	Process Options	Implementability	Effectiveness	Cost	Screening Decision
Institutional Controls	NA	NA	Moderate	Low	Low	Retained

4.3.3 Monitored Natural Recovery

Natural recovery is the process by which contaminant concentrations in sediment are reduced through a combination of physical, biological, and chemical processes so that surface sediment concentrations are reduced to acceptable levels within a reasonable timeframe (e.g., on the order of 10 to 20 years). Physical processes act to either bury surface sediment with newly deposited sediments or mix surficial sediment with deeper subsurface sediments through bioturbation, propwash, or other mixing influences. Due to the high degree of large vessel usage in the EW, propwash impacts are considered to be a significant factor in the feasibility of using MNR in the EW. Biological processes can be effective at degrading certain organic compounds, reducing mass and/or toxicity. However, biological processes are typically not effective at significantly reducing PCB and metals within a reasonable recovery timeframe (EPA and USACE 2000). Chemical processes, such as absorption of organic chemicals to carbon sources, also may assist with natural recovery.

MNR relies on the natural recovery processes described above, plus includes long-term monitoring to ensure that natural recovery is occurring as predicted. Predictive modeling of natural recovery processes using site-specific tools (such as the sediment transport evaluation) can be performed to predict sediment recovery rates by assessing the rate at which new sediments from upstream deposit or mix with existing sediments. Performance monitoring of sediments at specified intervals can be performed to verify model predictions and to document the presence and effectiveness of the natural processes in reducing risks.

MNR differs from the No Action technology since MNR must assess the potential for recontamination, provides a prediction for long-term effectiveness through modeling of the various natural recovery processes, and employs long-term monitoring and adaptive management to ensure the remedy achieves RAOs (Palermo 2002) or to determine whether additional remedial action may be required if MNR does not occur as predicted. Source control, recontamination potential, and natural recovery modeling evaluations will be conducted as part of the FS. For this Screening Memo, it is assumed that the FS evaluation will demonstrate that long-term natural recovery processes will reduce the surface concentrations within the EW; however, this Screening Memo does not make an assumption as to the level of reduction achieved through MNR.

4.3.3.1 Implementability

MNR is technically implementable in all CMAs, as supported through the use of predictive modeling to determine areas where natural processes support natural recovery, and long-term monitoring. MNR has been approved for use on contaminated sediment sites, though typically not as the sole remedial action. MNR is considered administratively implementable.

4.3.3.2 Effectiveness

MNR technology has been demonstrated to be effective at numerous contaminated sediment remediation sites. Within the EW, MNR may be effective in areas where sediment deposition may provide a source of clean sediment deposition within impacted areas, or in areas where degradation of contaminants may be expected (e.g., for certain organic contaminants subject to degradation) to reduce sediment concentrations to below risk levels within reasonable timeframes. MNR's effectiveness may be limited in certain CMAs due to vessel propwash (as evaluated in the Draft STER; Anchor QEA and Coast and Harbor 2011) causing significant resuspension and mixing in CMAs with frequent vessel usage (e.g., Federal Navigation Channel). MNR technology's overall effectiveness is considered to be moderate relative to active remediation technologies due to the greater degree of uncertainty about the performance of MNR within the EW.

4.3.3.3 Cost

Costs in general are considered to be low since no active remediation takes place, and costs are primarily related to long-term monitoring costs.

4.3.3.4 Summary

MNR is retained as a remedial technology (Table 6).

Table 6
Summary of Screening of MNR

GRA	Technology Type	Process Options	Implement-ability	Effectiveness	Cost	Screening Decision
Monitored Natural Recovery	NA	Sedimentation	High	Moderate (due to higher degree of uncertainty relative to active remediation technologies)	Low	Retained

4.3.4 Enhanced Natural Recovery

ENR, while a form of natural recovery, is considered an active remediation technology and involves placement of a layer of clean material over sediment with relatively low to moderate contaminant concentration levels to expedite the natural recovery process. The natural recovery process includes physical processes (e.g., sedimentation, advection, diffusion, dilution, dispersion, bioturbation, and volatilization), biological processes (e.g., biodegradation, biotransformation, phytoremediation, and biological stabilization), and chemical processes (e.g., oxidation/reduction, sorption, or other processes resulting in stabilization or reduced bioavailability) (EPA 2005). With ENR, the natural recovery process is accelerated by adding a layer of clean sediment over contaminated sediment that can mix the clean material with the underlying contaminants from bioturbation or vessel propwash (EPA 2005). ENR is placed over areas that are predicted to undergo natural recovery, but at a recovery rate that is insufficient to achieve RAOs within a reasonable timeframe. ENR placement is intended to speed up burial processes; the ENR layer is not intended to provide complete containment of the underlying contaminated sediments, but generally provides for a cleaner substrate and sufficient initial isolation that along with future deposition of new material, reduces migration of contaminants. Long-term monitoring is typically a component of ENR to document that predicted natural recovery is occurring.

4.3.4.1 Implementability

ENR is technically implementable, as supported by the use of predictive modeling, to determine areas where natural processes support natural recovery, clean cover placement, and long-term monitoring. Placement of ENR clean cover material can be accomplished using readily available equipment options. Example placement methods are shown in Figure 13; however, other methods may also be implemented. ENR can be placed in all CMAs. ENR placement in Underpier CMAs is more difficult due to equipment inaccessibility and steep underpier side slopes, but is considered feasible. ENR has been approved for remedial action on many contaminated sediment sites, and is considered administratively implementable.

4.3.4.2 Effectiveness

ENR has been shown to be effective at reducing sediment concentrations in CERCLA sites within the Puget Sound, such as Commencement Bay (Tacoma, Washington), Eagle Harbor (Bainbridge Island, Washington), Puget Sound Naval Shipyard (Kitsap County, Washington), and at the Ketchikan Pulp site (Ketchikan, Alaska) (Thompson et al. 2003). Within the EW, ENR could be considered for areas of relatively low to moderate contaminant concentrations, that are predicted to naturally recover, or where engineered capping (discussed in the next section) would be difficult to implement. ENR's effectiveness may be limited in certain CMAs due to vessel propwash (as evaluated in the Draft STER; Anchor QEA and Coast and Harbor 2011) causing significant resuspension and mixing in CMAs with frequent vessel usage (e.g., Federal Navigation Channel). ENR technology's overall effectiveness is considered to be moderate relative to other active remediation technologies due to the greater degree of uncertainty about the performance of ENR within the EW.

4.3.4.3 Cost

The ENR costs are considered to be low to moderate since this technology involves careful placement of clean cover material, along with long-term monitoring and potentially long-term maintenance needs should monitoring indicate the need to replenish the ENR layer.

4.3.4.4 Summary

ENR is retained as a potential remedial technology (Table 7) with the above-noted limitations.

Table 7
Summary of Screening of ENR

GRA	Technology Type	Process Option	Implementability	Effectiveness	Cost	Screening Decision
Enhanced Natural Recovery	NA	Thin-layer placement of clean sediment	High	Moderate (due to higher degree of uncertainty relative to other active remediation technologies)	Low to Moderate	Retained

4.3.5 In situ Containment (Capping)

In situ containment refers to the placement of an engineered subaqueous covering or cap of clean material on top of contaminated sediment that will remain in place. A cap would be designed to effectively contain and isolate contaminated sediments from the biologically active surface zone. As described in *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 2005), in situ caps (and ENR) can quickly reduce exposure to contaminants and typically require less infrastructure than ex situ technologies (e.g., dewatering, treatment, and disposal). Since capping leaves contaminated sediments in place, long-term monitoring is typically a component of in situ containment to ensure that the cap is stable (i.e., not eroding) and continues to effectively isolate contaminants, or sufficiently attenuate contaminant mobility through the cap (EPA 2005).

Detailed guidance manuals for in situ containment for contaminated sediments have been developed by USACE and EPA (Palermo et al. 1998a, 1998b). This Screening Memo intends to provide a general overview of in situ containment technology and refers the reader to USACE and EPA guidance manuals for detailed information on cap design for contaminated sediments.

The required minimum cap thickness is based on the physical and chemical characteristics of the contaminated and capping sediments, erosion potential from natural or anthropogenic sources, potential for bioturbation of the cap from aquatic organisms, potential for consolidation of the cap and underlying sediments, and operations considerations (Palermo et al. 1998a). Total thickness can be composed of cap layers for bioturbation, consolidation, erosion, operational considerations, and chemical isolation.

A typical cap thickness of up to 3 feet of clean material has been used at many sites (EPA 2005). However, the EW experiences erosive forces from propwash effects from large container ships and tugboats that use the waterway. Preliminary evaluation of propwash in the Draft STER (Anchor QEA and Coast and Harbor 2011) indicates there will likely be a need for cap armoring for a cap placed within CMAs in the EW that experience significant propwash forces. For the Screening Memo, a conceptual cap thickness of 5 feet (i.e., 4 feet design cap thickness plus 1 foot overplacement tolerance that includes a chemical isolation layer, filter layer, and armor layer) is assumed for use in developing conceptual-level construction costs. Figure 14 shows typical armored engineered cap cross sections. The FS will use the propwash results from the final STER, biological information from the SRI, and contaminant mobility modeling to develop a preliminary design that may revise both the cap components and the minimum cap thickness.

Other cap options include the use of a low-permeability cap, comprised of a natural material such as clay, a synthetic material such as HDPE, or combinations such as geosynthetic clay liners. Low-permeability caps offer similar advantages and disadvantages to sediment caps and incorporate a hydraulic containment component. Low-permeability caps are significantly more difficult to construct and have not been implemented on many large-scale projects.

Reactive capping is a technology that typically includes addition of sorptive capacity of the cap, depending on the type of contaminant present, to reduce the flux of contaminants from underlying sediments to shallow porewater and the water column. Use of reactive materials may also be warranted where evaluations of standard capping indicate that a sufficiently thick cap cannot be created to adequately reduce the flux of contaminants over time, which may be due to a variety of reasons singly or in combination, such as the presence of highly mobile contaminants, high rates of groundwater advection, and/or the need to maintain certain water depths for navigation or habitat purposes. As described in EPA (2005), examples of materials used in reactive caps include engineered clay aggregate materials, and reactive/adsorptive materials such as activated carbon, apatite, coke, organoclay, zero-valent iron, and zeolite. Composite geotextile mats containing one or more of these materials (i.e., reactive core mats) are available commercially. To date, caps with reactive layers have tended to be used in areas with higher underlying sediment concentrations of highly mobile contaminants. Reactive capping is still a relatively new technology and should be subject to further review and evaluation of site-specific chemical and physical conditions.

Capping placement can be accomplished using a number of mechanical and hydraulic methods (Figure 15). Placing sand- and gravel-sized materials in a controlled fashion is relatively easy to do under adequate site conditions (e.g., low currents, calm sea state, lack of physical restrictions, and relatively flat bottoms), and can be accomplished with a variety of equipment such as:

- Controlled discharge from hopper barges
- Hydraulic pipeline delivery of a sand slurry through a floating spreader box or submerged diffuser
- Physical dispersion of barge stockpile capping materials by dozing, clamming, conveyoring, or hydraulic spraying of stockpiled material off the barge and into the water column
- Mechanically-fed tremie tube to contain lateral spread of the cap material until it reaches the bottom of the water column

Sand and gravel placement can often be accomplished in more difficult access areas through the use of conveyors or hydraulic pipeline discharge. However, steep side slopes are a critical limitation to cap placement due to the ability of cap material to be placed and stay stable on steep slopes. Placement of an armor layer made of cobbles or rocks is more complicated than sand and gravel placement, and requires a greater degree of operator skill to avoid overplacing the rock armor layer or prevent missing areas of required armoring. The placement equipment for rock is typically limited to mechanical equipment since hydraulic pipelines and conveyors are limited as to the size materials they can effectively transport. Rock placement is also limited on steep slopes.

4.3.5.1 Implementability

Capping is technically implementable in most of the CMAs within the EW. It is anticipated (based on preliminary results from the Draft STER; Anchor QEA and Coast and Harbor 2011) that armoring the cap against vessel propwash and natural erosive forces is feasible and would be required to prevent potential cap erosion in many CMAs. Most of the EW is unrestricted open water and it is feasible to place an engineered cap in waterway areas that do not have overwater piers. For the Underpier CMAs, capping likely is infeasible to place due to equipment inaccessibility, structural and slope stability impacts from placing added weight, and likely infeasibility of placing a stable cap on steep underpier side slopes, which have been designed to approximate 1.75 horizontal to 1 vertical (1.75H:1V) for Port facilities and 2H:1V for USCG piers. As a comparison, temporary stable slopes for sand and gravel mix underwater may be as steep as 3H:1V or 2.75H:1V with careful placement (based on experience, also: NavFac 1986). For the Sill Reach CMA, capping may be difficult to place due to access issues underneath the existing bridge structures. However, the Sill Reach does not have the steep slopes that the Underpier CMAs have.

Low-permeability caps are significantly more difficult to construct than conventional caps due to working with either clays and/or low-permeability liner that both require specialized equipment to place. Low-permeability caps have not been proven to be technically implementable for sites with deep water depths and accessibility issues. Therefore, implementability of low-permeability caps is considered to be low.

Incorporation of amendments into an engineered cap (e.g., reactive capping) can limit implementability of capping, but it is still considered technically implementable. Reactive capping is an implementable way to introduce treatment components into areas where in situ treatment alone may not be implementable, for example, where wave or propwash forces are particularly strong, and make the implementability of in situ treatment by itself uncertain. Reactive caps, like engineered capping, could be considered as part of a dredge and cap option in some areas in remedial design.

From an administrative standpoint, capping is not considered to be implementable in most of the EW as a stand-alone remedy without incorporating dredging, due to maintained navigation and berthing depth. The Federal Navigation Channel, Berth Areas, Slip 27, and Slip 36 CMAs have minimum water depths that would need to be maintained. Future deepening of these navigation and berth areas may also need to be considered as part of a cap design. In such cases, the final elevation of the top of the placed cap would be equal to or below the authorized Federal Navigation Channel elevation or facility berth elevations. This requires that those navigation and berth areas be dredged to accommodate the maximum cap thickness to avoid overplacing the cap above the channel or berth minimum elevations. For the LDW RI/FS project, USACE sent a clarification letter to EPA to provide interim guidance that would require that a buffer be established between the maintained Federal Navigation Channel elevation and lateral limits and any proposed capping (USACE 2010). This clarification required that the final cap elevation should equal authorized depth plus 2-foot overdepth and an additional 2-foot buffer zone for cap protection, and that the horizontal edge of the cap be at least 10 feet from the federal navigation channel boundary (USACE 2010). This guidance will be reviewed and evaluated for applicability to the EW federal navigation channel during the FS and remedial design stages, as specific operational and institutional considerations in the EW may be different than in the LDW.

4.3.5.2 Effectiveness

Capping is considered an effective remedial technology for all COCs in the EW, especially for highly sorbed contaminants such as PCBs. Capping has been shown to be a reliable and proven technology that has been effective at many CERCLA sites within the Puget Sound, such as Commencement Bay (Tacoma, Washington), Eagle Harbor (Bainbridge Island, Washington), Pacific Sound Resources (Seattle, Washington), Georgia-Pacific Log Pond (Bellingham, Washington), and throughout the United States. Incorporation of amendments into an engineered cap (e.g., reactive capping) can improve the effectiveness of capping technology by reducing mobility through the cap of certain contaminants. Reactive caps, including those with Granulated Activated Carbon (GAC), would need to be evaluated to confirm they could withstand specific propwash forces. Since capping disturbs relatively little in situ contaminated sediment, capping technology is considered to have relatively few environmental impacts during construction. Overall, capping technology is considered to have a high ranking for effectiveness.

4.3.5.3 Cost

Capping is considered a moderate cost technology due to the expense of the materials, installation (especially in complex, multiple-layer caps), and long-term monitoring and maintenance requirements. Costs can be high if extensive removal is required to maintain navigation or berthing depths.

4.3.5.4 Summary

Capping is retained as a potential remedial technology (Table 8) with the above-noted limitations.

Table 8
Summary of Screening of Capping

GRA	Technology Type	Process Option	Implementability	Effectiveness	Cost	Screening Decision
In situ Containment	Capping	Conventional Cap	Moderate	High	Moderate	Retained
		Low Permeability Cap	Low	High	Moderate to High	Not Retained
		Reactive Cap	Low	High	Moderate to High	Retained

4.3.6 Removal

Removal can result in the least uncertainty with respect to long-term effectiveness of a remedy (EPA 2005), but can result in short-term water quality impacts from dredging releases that can increase fish and shellfish tissue concentrations (Bridges et al. 2010). Removal also provides for flexibility in future uses of the waterway. There are also limitations associated with contaminated sediment removal (EPA 2005). Site restrictions and existing structures can limit the ability to remove all contaminated sediment within the waterway. Removal results in greater short-term environmental impacts from contaminated sediment loss and resuspension than other remedial technologies.

Detailed guidance manuals for environmental dredging of contaminated sediments have been developed by USACE and EPA (Palermo et al. 2008; EPA 2005). This Screening Memo intends to provide a general overview of removal technologies and refers the reader to USACE and EPA guidance manuals for detailed information on environmental dredging for contaminated sediments.

Dredging and excavation are the two most common technologies for removing contaminated sediment from a waterbody (EPA 2005), either while the sediment is submerged (dredging) or after water has been diverted or drained (excavation). Removal requires handling of dredged or excavated sediment including dewatering, offloading, transport, treatment (if required), and disposal, each of which involves additional costs and the potential for further releases. The full process of removal is often referred to as the "treatment or process train."

Both removal technologies along with several associated process options, as listed below, are discussed in more detail:

- Dry excavation using standard earthwork equipment
- Dredging using mechanical, hydraulic, or underpier dredging equipment

4.3.6.1 *Dry Excavation*

Sediment excavation involves the use of excavators, backhoes, and other conventional earth moving equipment to remove contaminated sediment after water has been diverted or drained (i.e., "in the dry" removal) (Figure 16). Diversion of water of the excavation area can be facilitated through the installation of temporary cofferdams, sheetpiling, or other water management structures and the subsequent lowering of the surface water elevation within the excavation area. Following dewatering of the area, equipment can be positioned on the bed within the excavation area or immediately adjacent to the dewatered excavation area. However, dry excavation is not considered feasible for most areas within the EW. The EW has water depths that can extend deeper than 50 feet, which make it infeasible to consider dry excavation for use in the entire site. The EW also is an active navigation area for deep draft container ships and other shallower draft vessels. There may be limited areas near open shorelines where dry excavation could potentially be used. However, engineering evaluations would need to be conducted to confirm that installation of a temporary cofferdam or sheetpile wall could be constructed, considering the sediment/geotechnical properties and hydrodynamic changes that could result from diversion of water from the excavation area and subsequent temporary narrowing of the waterway width in the Sill Reach. For purposes of this Screening Memo, dry excavation will not be discussed further in the Screening Memo, but will be addressed in more detail in the FS as a potential removal technology that has limited application within the EW.

4.3.6.2 *Dredging*

Dredging is a method of excavation that allows the removal of sediments without water diversion or draining (i.e., "in the wet" removal). Dredging is generally accomplished using either hydraulic or mechanical floating equipment (Figure 17). Regardless of the dredging method and use of dredging best management practices (BMPs), short-term water quality impacts, and residual contamination post-dredging are inherent to the dredging process and need to be planned for (USACE 2008). Short-term water quality impacts from dredging releases can lead to increased fish and shellfish tissue concentrations. Dredging BMPs that are typically employed to help comply with water quality criteria include operational controls, barriers such as silt curtains, specialized dredging equipment such as closed buckets, and water quality monitoring.

All dredging projects result in some degree of resuspension, release, and residuals (NRC 2007). Residual contamination is defined as both contaminated sediment that remains un-dredged due to the inability to be 100% accurate in delineating all of the contaminated sediment, or contaminated sediment that was resuspended during dredging and that could not be fully captured (i.e., due to removal equipment limitations in preventing loss of sediment during the action of dredging) (Figure 18). The need to address residual contamination post-dredging depends upon the concentrations and thicknesses of residuals remaining. However, empirical data from numerous sediment remediation projects indicate that residual contamination is a common occurrence and that sites with high concentrations are unlikely to achieve their RAOs with dredge technology alone (Patmont and Palermo 2007; NRC 2007). Placing a thin clean sediment cover as a final step in the remediation process has been successfully used to manage residuals to achieve cleanup levels on the surface post-construction (Figure 19). Most recent sediment remediation project designs include placing a residuals cover as either the primary or secondary residuals management technology (e.g., East Waterway Phase 1 Removal Action, Port of Olympia Berths 2 and 3 Interim Action, Port Gamble Wood Waste Removal, Denny Way Interim Action). For purposes of this Screening Memo, the dredging alternative will assume that a residuals management cover will be placed in all areas where dredging occurs.

4.3.6.2.1 Mechanical Dredging

Mechanical dredges have been used extensively in the Puget Sound for sediment remediation projects and are widely available. Mechanical dredges are designed to remove sediment at or near in situ density (EPA 2005), though some amount of excess water is typically entrained in the dredge bucket as it closes and is lifted up through the water column. The quantity of water generated using mechanical dredging is orders of magnitude less than that generated with hydraulic dredging. Mechanical dredges are capable of effectively removing consolidated sediment, debris, and other materials such as piling and riprap. The barge-mounted crane can use different types of buckets or attachments to dredge or assist with demolition activities. Mechanical dredges are capable of working in difficult-to-access areas, and are relatively easy to relocate, thus reducing the potential impact to existing site operations. However, mechanical dredges are unable to effectively work under low clearance overwater structures to remove sediment.

A typical "treatment or process train" for mechanical dredging (assuming landfill disposal) is listed below:

- Dredge contaminated sediment
- Place contaminated sediment in a haul barge
- Passive dewatering on the barge
- Transport contaminated sediment to either an on-site or off-site offloading/staging area (Figure 20)
- Offload sediment to a stockpile area for either passive or active dewatering. Dewatering methods may include working the sediment, additives, filter or belt presses, hydrocyclones, or other methods.
- Treat effluent from the stockpile and discharge to receiving waters or approved publically owned treatment works (POTW)
- Transport contaminated sediment over land by truck or rail
- Dispose contaminated sediment at a landfill facility

Mechanical dredging is considered feasible for open-water areas because of its effective removal of consolidated sediment, debris, and other materials such as piling and riprap and ability to relocate, thus reducing the potential impact to existing site operations. In underpier areas, mechanical dredging would be infeasible due to equipment inaccessibility.

4.3.6.2.2 Hydraulic Dredging

Hydraulic dredging typically involves using a cutterhead or similar equipment to remove sediments from the sediment bed. Hydraulically dredged material can be transported via piping directly to a staging/processing area. The hydraulic transport pipeline is typically a floating pipeline, which can interfere with vessel navigation. Relative to mechanical dredging, a significantly greater volume of water is entrained with the sediment slurry removed by the dredge and must be subsequently separated from the sediment solids and treated and discharged (EPA 2005). The solids content of hydraulically-dredged slurries typically averages about 10% by weight, but it can vary considerably with the specific gravity, grain size, and distribution of the sediment, and depth and thickness of the dredge cut. In general, hydraulic dredges cannot remove rocks and large debris. Hydraulic dredging has been implemented at many contaminated sediment sites, although hydraulic dredging has been used much less frequently than mechanical dredging at sediment remediation sites in Puget Sound.

Dewatering of hydraulically dredged sediments is required prior to upland transport and disposal. Hydraulically-dredged sediments can be dewatered using passive or active methods, and typically requires use of large settling basins due to the relatively large volume of water added for slurry transport. Dewatering requires an upland staging area, usually in close proximity to the dredge area due to the difficulties in placing, operating, and maintaining long distances of pipeline over land. The EW OU has limited space in the upland area close to the EW not already under a long-term lease.

Hydraulic dredging, as the primary removal technology, is not considered practical for the EW for reasons identified below, and is not carried forward as a remedial technology except for hydraulic dredging of the underpier area as discussed in the next section:

- Hydraulic dredging produces a slurry that requires a large area for settling, dewatering, and stockpiling. The EW likely does not have on-site locations that are not in long-term use and have sufficient space to handle hydraulic dredging upland needs.
- The hydraulic pipeline can be a significant impediment to site access and use and could adversely impact the ability for the Port, USCG, and others to use the waterway.
- The EW is anticipated to have a significant amount of debris in nearshore areas that can significantly reduce a hydraulic dredge's effectiveness.
- Hydraulic dredging in water depths (greater than 60 feet) like that present in the EW may require submerged pumps, which can be challenging to maintain.

4.3.6.2.3 Underpier Dredging

Removing contaminated sediment from underpier locations presents significant engineering and construction challenges. The two options are generally described as either demolishing most or all of the existing structures in order to provide unobstructed access to remove the contaminated sediment, or working around existing structures to remove as much of the contaminated sediment as feasible. It is not possible to remove 100% of the contaminated sediment from underpier areas without completely removing the existing infrastructure since contamination is generally associated with some marine construction materials, such as creosoted piling, and contaminated sediment is likely embedded within riprap areas. Riprap slopes are often constructed in underpier areas to provide slope stabilization or wave and propwash protection purposes, and contaminated sediment fills in the interstices of the riprap making it impossible to remove 100% of the contaminated sediment using dredging methods. Residuals management needs to be considered as part of both options.

Due to interruptions in use and costs associated with complete demolition and rebuild of facilities, most underpier removal actions focus on removing as much of the contaminated sediment as practical and use residuals management strategies, such as placing clean sediment cover (i.e., residuals cover) over dredged areas to reduce potential impacts from remaining residuals.

The feasibility of underpier dredging is dependent upon the pier design (e.g., pile spacing, deck elevation, and other obstructions), presence of debris and broken-off piling, underpier slope geotechnical conditions, and ability of equipment to access the underpier area without potentially damaging the existing structure. Diver-assisted hydraulic dredging has been used to remove contaminated sediment located under piers (e.g., Sitcum Waterway Remediation, Tacoma, Washington). However diver-assisted dredging has significant issues including low production rates, inability to remove consolidated sediment, inability to remove debris, and safety concerns. Underpier hydraulic dredging has the same considerations as standard hydraulic dredging, such as use of a hydraulic pipeline, extensive water management needs, and the likely need to dewater the sediment.

Portions of the underpier areas can potentially be mechanically dredged, provided there is sufficient clearance, including having sufficient space between the bottom of the concrete deck and the water surface for the long-reach excavator to access the sediment, and not having obstructions that would prevent equipment access. Mechanical dredging underpier cannot directly remove sediment from the sediment bed to the surface in one action, due to the presence of the pier deck. Therefore, underpier dredging by mechanical methods typically involves dragging sediment from the underpier area downslope out into the toe of slope where additional equipment can be used to re-dredge the sediment and lift it to a haul barge.

For this Screening Memo, only diver-assisted hydraulic dredging is considered suitable for use in underpier areas since mechanical dredging may pose unacceptable risks for damaging the existing structures and/or underpier riprap slopes.

4.3.6.3 Implementability

Dry excavation as a primary removal technology is not considered to be technically implementable throughout most of the site due to water depth and site use considerations, though it potentially can be used in limited areas along the nearshore where site access is available. Dredging as a primary removal technology is considered to be technically implementable for the EW. Mechanical dredging, as a primary process option, is technically implementable in most of the CMAs within the EW. Most of the EW is unrestricted open water, and it is feasible to use conventional mechanical dredging equipment to dredge those areas. Hydraulic dredging, as a primary process option, is not considered to be technically implementable due to water management issues and equipment (i.e., floating pipeline), impacts to navigation, and technical feasibility at waterway depths. For the Underpier CMAs, dredging using diver-assisted methods is considered technically implementable, though with significant design and construction issues. Dredging may need to be restricted adjacent to existing structures and/or slopes to avoid adversely impacting their stability. Table 3 summarizes critical site restrictions within EW CMAs that may impact the ability to fully remove all contaminated sediment.

From an administrative standpoint, removal by dredging is considered to be implementable. Maintained portions of the Federal Navigation Channel, Berth Area, Slip 27, and Slip 36 CMAs have minimum water depths that dredging would help maintain. Removal by dredging has been accepted as a primary remedial technology on numerous contaminated sediment sites throughout the United States. Removal by dredging is considered to have a moderate to high rank for implementability, depending upon the various process options, except in limited areas with critical site restrictions that may limit its use in certain CMAs.

4.3.6.4 Effectiveness

Removal has been proven to be an effective technology for achieving cleanup goals when used in combination with residuals management[2]. Each process option discussed above can be effective given the appropriate site conditions, and must consider critical site restrictions.

Removal technologies will not remove 100% of the contaminated sediment, leaving behind contaminated residuals. The residual sediment reduces the risk-reduction of the remedy, and consequently, reduces the effectiveness of the dredging remedy (NRC 2007). Research has shown that residual sediment remaining on the post-dredge surface (typically ranging from 2% to 11% of the remaining contaminated sediment mass prior to the final production dredge pass) have been observed during most environmental dredging projects, particularly when targeted sediments overlie a layer of hard material (e.g., rock or till) and where rocks/cobbles, logs, or other debris are present on the river bottom (Desrosiers and Patmont 2009). Management of potential post-removal residuals, either by placement of backfill/sand cover or natural recovery, is commonly considered in the evaluation of excavation or dredging as a removal technology. For all removal technologies, effectiveness is improved by application of a residuals management cover, and this Screening Memo assumes that a residuals management cover will be placed in all dredged areas.

Removal by dredging can handle the estimated volume of contaminated sediment to achieve the surrogate RALs. Dredging is also considered to be a proven and reliable remedial technology and suitable for use in the EW. Dredging does result in release of contaminants during construction (i.e., dissolved or sorbed to suspended sediment particles) to the water column, and potential sediment transport will likely result in water quality impacts during dredging even if the removal area is enclosed by turbidity control devices or other dredging

[2] Residuals management includes placement of a thin clean sediment cover as a final step in the remediation process to achieve cleanup levels on the surface post-construction.

BMPs are used. Whereas sediment turbidity impacts in the removal area can be minimized in certain applications through the use of BMPs such as silt curtains, such BMPs have been demonstrated to be generally ineffective in areas with large tidal excursions and in generally reducing the release of dissolved contaminants from any site. Therefore, dredging technology is considered to have a ranking between moderate and high for effectiveness.

4.3.6.5 Cost

Dry excavation is not feasible for the entire EW, but potentially may be used in some portions of the shallow nearshore. The cost for removal by dredging, both hydraulic and mechanical, is high. Removal costs not only include the cost of dredging, but also all of the ancillary construction elements that are part of the overall "treatment or process train." These ancillary construction elements may include: pre-dredge debris removal, staging and stockpile area preparation, dewatering, water treatment, sediment stabilization, transport, landfill disposal tipping fees (or other disposal technology costs), and environmental monitoring.

4.3.6.6 Summary

Sediment removal by dredging and potentially dry excavation (in limited areas) is retained as a potential remedial technology (Table 9) with the above-noted limitations.

Table 9
Summary of Screening of Removal Options

GRA	Technology Type	Process Option	Implementability	Effectiveness	Cost	Screening Decision
Removal	Dry Excavation	Soil Excavators	Low	Moderate to High (in areas where it is implementable)	High	Retained (in limited areas)
	Dredging	Mechanical Dredging	Moderate to High	Moderate to High	High	Retained
		Hydraulic Dredging	Low in Open-water Areas; Low to Moderate in Underpier Areas	Moderate to High	High	Retained for Underpier Areas; Not Retained Elsewhere

4.3.7 Treatment Technologies

Treatment technologies refer to chemical, physical, and biological process options that can be applied to contaminated sediment, either in situ or ex situ, to reduce concentrations, immobilize the contaminants, or reduce bioavailability of contaminants to biota. Treatment technologies have been reviewed as part of the LDW RI/FS and included in the *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005), as well as the *Lockheed West Seattle Superfund Site Final Screening of Remedial Technologies and Assembly of Preliminary Alternatives* (Tetra Tech 2010). These previous treatment evaluations have been accepted by EPA Region 10, and are relevant to the EW based on proximity of the sites to each other, similar site conditions, and similar COCs. The evaluation conducted for the LDW and Lockheed West Seattle in those reports form the basis of the treatment screening for this Screening Memo. Various treatment technologies were eliminated as part of the LDW treatment technology evaluation, and for the same reasons, are also eliminated from consideration for the EW. Those eliminated technologies include both in situ and ex situ technologies, and are briefly discussed in the following sections.

4.3.7.1 In situ Treatment

In situ sediment treatment technologies include sequestering agents (e.g., activated carbon), biological or chemical degradation, immobilization, and other potentially appropriate treatment technologies to reduce levels or mobility of sediment contaminants while leaving sediments in place. As part of the LDW RI/FS, many in situ treatment technologies were reviewed, and subsequently eliminated from further consideration, as they were considered not feasible and have not been tested at full scale. Elimination of these specific in situ treatment technologies is consistent with EPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*, which states that "...for the majority of sediment removed from Superfund sites, treatment is not conducted prior to disposal, generally because sediment sites often have widespread low-level contamination, which the National Contingency Plan (NCP) acknowledges is more difficult to treat" (EPA 2005).

EPA has recently supported in situ application of amendments as an in situ treatment (Figure 21). GAC has been demonstrated to reduce the bioavailability of several contaminants, including PAHs, PCBs, dioxins/furans, dichloro-diphenyl-trichloroethane (DDT), and mercury, when directly mixed into sediment (EPA 2011; Ghosh et al. 2011). GAC has been added as an amendment to both sand cover and bentonite (Cornelissen et al. 2011; Oen and Cornelissen 2010; Oen et al. 2011). This type of in situ treatment is most applicable to sediment in the biologically active zone (i.e., approximately the upper 0 to 10 cm of sediment). Another type of amendment used as an in situ treatment includes addition of organoclay to a standard ENR sand cover to reduce the bioavailability for non-soluble organics and potentially other contaminants. Considering the range of COCs identified in EW, in situ sediment treatment is a potential remedial technology. The GAC process option has been demonstrated to be effective in the short term (limited long-term data are available) for organic contaminants at several remediation project sites including the Grasse River in Massena, New York (Ghosh 2010; Alcoa 2010), Hunter's Point Naval Shipyard in San Francisco, California (Luthy et al. 2009; Cho et al. 2009; Janssen et al. 2009, 2011), Aberdeen Proving Ground in Maryland (Menzie 2011a, 2011b), U.S. Army Installation in Virginia (Menzie 2011a, 2011b), and at several sites in Norway (Oen and Cornelissen 2010; Oen et al. 2011). Successful GAC placement has occurred at these sites using rotary tilling, injection, broadcasting, and with a "tine sled" device that directly injected GAC into near-surface sediment. At the sites in Norway, pre-mixing GAC with another medium (e.g., sand) prior to placement was found to accelerate the natural bioturbation process, resulting in a more homogeneous long-term application of GAC when placed in shallow water depths or in the "dry" (Oen and Cornelissen 2010; Oen et al. 2011).

Treatment technologies were reviewed as part of the LDW *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005), and were not retained with the exception of GAC. Use of organoclays as in situ treatment has also been retained and is being reviewed in the LDW FS. No in situ treatment technologies are considered innovative. In situ treatment technologies are summarized in Table 10.

4.3.7.2 Ex situ Treatment

Ex situ treatment refers to technologies that immobilize, transform, or destroy COCs after first removing contaminated sediment from the bed. Treatment processes may be classified as biological, chemical, physical, or thermal. Ex situ thermal treatment is generally considered the most effective method of ex situ treatment since the other treatment processes are currently not able to remediate the broad categories of COCs found in many contaminated sediments. Thermal treatment includes four subcategories: incineration, high-temperature thermal desorption (HTTD), low-temperature thermal desorption (LTTD), and vitrification. Because the costs for ex situ treatment are typically very high, and the treated material still typically requires disposal, the decision to include ex situ treatment often is driven by other reasons than effectiveness in achieving surrogate RALs or environmental protectiveness. In rare cases, ex situ treatment may help to reduce overall project costs if the costs of disposal technologies are so high that the addition of ex situ treatment plus a reduced level of disposal is less costly than disposal at a more protective disposal facility.

The LDW *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005) evaluated and retained several ex situ treatment process options (i.e., separation, stabilization, incineration, and vitrification). For the EW, the separation ex situ treatment process option may be considered during the FS and/or Remedial Design to assess whether adding this ex situ treatment process option to the overall removal "treatment or process train" helps to reduce overall remediation costs. As discussed in the LDW *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005), to date, ex situ treatment of sediments has been mostly limited to soil washing in full-scale sediment remediation projects. Technologies that destroy or detoxify contaminants using physical, chemical, or thermal technologies have been accepted at very few projects for cleanup at contaminated sediment sites for two reasons. First, it is difficult to balance treatment costs with a beneficial reuse outlet for the material; and second, upland and in-water disposal alternatives are much less expensive, particularly in this region. With the exception of the addition of cement-type materials to reduce free water content and mobility prior to upland disposal, no contaminated sediment remediation projects in this region have utilized large scale treatment or beneficial reuse of treated sediments. In addition, many ex situ technologies are either not commercially available or have not been applied on a similar site and scale as the EW, including vitrification and incineration; incineration is not effective for metals. Therefore, stabilization, incineration, and vitrification will not be retained in the FS.

Other ex situ treatment technologies summarized in Table 10 were evaluated in the LDW *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005), and were not retained. No additional information has become available that would change the conclusions presented in that report. Separation will be retained for limited high concentration sediments, which may be more economical to treat than dispose (Table 10).

4.3.7.3 Implementability

For in situ treatment, the placement of amended sands is technically feasible, though it can be a more complex process than ENR or Capping due to the need for mixing amendments into the ENR or Capping sands. For example, there have been difficulties with certain GAC applications due to the lighter density of GAC that may cause GAC to separate/float away from a sand/GAC mixture. As with placement of sand, placement of amendments in the Sill Reach and Underpier CMAs is significantly more difficult than other CMAs due to equipment access, but likely to be implementable if applied as part of an ENR approach. Amendments to reduce contaminant mobility are considered administratively implementable.

As discussed above, ex situ treatment is not described further for this Screening Memo, but may be considered during the FS and/or Remedial Design, if ex situ treatment post-removal is beneficial to the project costs. Ex situ treatment would likely be considered implementable if retained, provided adequate on-site staging or use of existing ex situ treatment facilities is available.

4.3.7.4 Effectiveness

Ex situ treatment technologies are generally considered to have low effectiveness due to lack of proven and reliable performance and inability to handle large volumes of contaminated sediment at a reasonable production rate. However, specific treatment technologies (e.g., in situ amendments and ex situ separation) rank moderate in effectiveness since they have been used successfully on larger-scale projects and potentially are capable of handling the estimated volume of EW contaminated sediment.

Amendments are generally considered to be effective due to the added amendments like organoclays and carbon that improve the ability to reduce contaminant mobility and bioavailability (EPA 2011; Ghosh et al. 2011). GAC, and potentially organoclays, may provide a reasonably effective technology for areas where dredging and/or engineered capping is not implementable due to critical site restrictions, such as underpier areas.

4.3.7.5 Cost

The costs associated with amendments are considered moderate due to the expense of the reactive material and the additional cost associated with installing an often neutrally buoyant material. On some sites, GAC placement has been implemented as an interim measure or has required long-term maintenance/replacement. Elsewhere, it has been designed for long-term permanence without replacement. Cost for separation are ranked high compared to other treatment alternatives.

4.3.7.6 Summary

In situ treatment, specifically the placement of amendments such as activated carbon, has been retained for evaluation in the development of alternatives in this Screening Memo. Other in situ treatment options that are not proven are not retained for further consideration (Table 10). Of the ex situ treatment options, separation is retained as a primary treatment process option because it has been applied at other contaminated sites in the United States, results in volume reduction of treated dredged material, and may result in a sand fraction suitable for beneficial use in the LDW, or possibly reduce or eliminate the cost of disposal for the sand fraction.

Table 10
Summary of Screening of Treatment Technologies

GRA	Technology Type	Process Option	Screening Decision
In situ Treatment	Physical-Immobilization	Amendments (e.g., Granulated Activated Carbon and organoclays)	Retained
		Stabilization	Not retained. Refer to Section 4.3.7.1 and Lower Duwamish Waterway
		Electro-chemical Oxidation	
		Vitrification	

Table 10

Summary of Screening of Treatment Technologies

GRA	Technology Type	Process Option	Screening Decision
		Ground Freezing	Candidate Cleanup Technologies (RETEC 2005)
	Biological	Slurry Biodegradation	
		Aerobic Biodegradation	
		Anaerobic Biodegradation	
		Imbiber Beads	
	Chemical	Slurry Oxidation	
		Oxidation	
	Physical-Extractive Processes	Oxidation	
		Sediment Flushing	
Ex situ Treatment	Physical/Chemical	Acid Extraction	Not retained. Refer to Section 4.3.7.2 and Lower Duwamish Waterway Candidate Cleanup Technologies (RETEC 2005)
		Solvent Extraction	
		Slurry Oxidation	
		Reduction/Oxidation	
		Dehalogenation	
		Sediment Washing	
		Radiolytic Detoxification	
	Biological	Enhanced Bioremediation	
		Slurry-phase Biological Treatment	
		Fungal Biodegradation	
		Landfarming/Composting	
		Biopiles	
	Physical	Separation	Retained
		Solar Detoxification	Not retained. Refer to Section 4.3.7.2 and Lower Duwamish Waterway Candidate Cleanup Technologies (RETEC 2005)
		Solidification	
	Thermal	Incineration	
		High-temperature Thermal Desorption (HTTD)	
		Low-temperature Thermal Desorption (LTTD)	
		Pryolysis	
		Vitrification	
		High-pressure Oxidation	

4.4 Preliminary Disposal Technologies

As described in the Workplan (Anchor and Windward 2007), this Screening Memo is required to identify and screen disposal alternatives for contaminated sediment and eliminate disposal site technologies that are not practical to implement. This section includes a general description of specific disposal alternatives, including confined aquatic disposal (CAD), nearshore confined disposal facilities (NCDFs), upland disposal sites, beneficial use of SMS suitable dredged material, upland commercial landfill options, and disposal of sediments at the Dredged Material Management Program (DMMP) open-water disposal site in Elliott Bay.

Regional and local disposal facilities and alternatives have been evaluated as part of previous studies in support of the Multi-User Disposal Site (MUDS) program (USACE et al. 1999). Additional evaluations of disposal technologies were conducted recently for the LDW Superfund Site as part of the *Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site* (RETEC 2005) and for the Lockheed West Superfund Site as part of the *Screening of Remedial Technologies and Assembly of Preliminary Alternatives Memorandum* (Tetra Tech 2010). This Screening Memo summarizes the outcome of the evaluations conducted as part of the disposal evaluations for LDW and Lockheed West, which have been reviewed and accepted by EPA, and relates the previous evaluations against EW conditions. Key documents relevant to disposal technologies for the EW that contributed to development of this section are listed below:

- Standards for Confined Disposal of Contaminated Sediments Development (Ecology 1990)
- Multi-User Sites for the Confined Disposal of Contaminated Sediments from Puget Sound (Ecology 1991)
- MUDS for Contaminated Sediments from Puget Sound – Subaqueous Capping and Confined Disposal Alternatives (USACE 1997)
- Puget Sound Confined Disposal Study Programmatic Environmental Impact Statement (USACE et al. 1999)
- MUDS Investigation (Ecology 2001)
- Puget Sound Confined Disposal Site Study (USACE 2003)

Off-site disposal of dredged sediment from a CERCLA site must be consistent with the Off-Site Rule (40 Code of Federal Regulations [CFR] 200.440). The purpose of the Off-Site Rule is to avoid having CERCLA wastes from response actions authorized or funded under CERCLA contribute to present or future environmental problems by directing these wastes to disposal areas determined to be environmentally sound. It requires that CERCLA wastes may only be placed in a facility operating in compliance with the Resource Conservation and Recovery Act (RCRA) or other applicable federal or state requirements. The Off-Site Rule establishes the criteria and procedures for determining whether facilities are acceptable for the receipt of CERCLA wastes from response actions authorized or funded under CERCLA. For this Screening Memo, any sediment taken outside of the EW OU study boundary for disposal purposes must comply with the Off-Site Rule. Each of the off-site disposal technologies, including off-site CAD, NCDF, and upland landfill, are expected to be reviewed by EPA in the context of this rule. As discussed in the Workplan (Anchor and Windward 2007), off-site aquatic disposal technologies are evaluated within the general bounds of the Duwamish River, EW, WW, and Elliott Bay.

The screening process described in this section evaluates potential sites for aquatic and upland disposal. A screening level evaluation of implementability, effectiveness, and cost is conducted for each disposal technologies. Those disposal technologies determined to be implementable and effective will be carried forward as viable disposal technologies for the more detailed evaluation in the FS Report.

4.4.1 Aquatic Disposal

4.4.1.1 Confined Aquatic Disposal

4.4.1.1.1 On-Site Confined Aquatic Disposal

CAD is a type of underwater sediment disposal that includes some form of lateral confinement (e.g., placement in natural or excavated bottom depressions or behind constructed berms) to minimize spread of the materials on the bottom (Figure 22). Construction of a CAD can include excavation of a bottom depression within which contaminated sediment may be placed, or level-bottom capping, in which contaminated sediment is placed on the existing relatively flat sediment surface. Similar to In situ Containment, a cap of clean material is used to isolate the marine environment from the contaminated sediment and prevent contaminant mobility through the cap. The cap also needs to be designed to account for potential erosive forces, bioturbation effects, and operational considerations.

A potential CAD alternative within the EW was previously developed in conceptual form as part of the EW Deepening Project in 2000 (Anchor 2000). A number of considerations and limitations associated with a CAD site in the EW make it logistically challenging and likely technically and administratively infeasible. These considerations include the presence of an active waterway with frequent ship traffic, a federally authorized navigation channel, the communication cable crossing in the vicinity of Station 1700, geotechnical stability to support a CAD site, and structural considerations that limit the extents of the CAD site along the east and west sides of the waterway. A description of an EW on-site conceptual CAD option, as previously developed, is described below, followed by a discussion of the implementability, effectiveness, and relative cost of this option.

The conceptual CAD option within the EW would be located between the 450-foot-wide Federal navigation channel limits of the EW, and extended from the mouth of the EW (Station 0) to Station 3000 in a series of three CAD disposal cells (Figure 23). The concept of using three separate disposal cells was to minimize the amount of overburden volume that would have to be disposed off-site if only one large CAD cell were constructed. Two cells located north of the communication cable crossing would each have approximate dimensions of 210 feet wide by 600 feet long at the base (or toe) of the CAD cell. The 210-foot width at the base of the CAD cell was considered the approximate maximum width because each CAD cell has to allow for side slopes and some setback distance from the side slope daylight line from the face of the terminals on either side of the EW. The third cell, located on the south side of the communication cable crossing, would be approximately 210 feet wide by 850 feet long at the base (or toe) of the CAD cell. The layout of the CAD cells would need to avoid encroachment on the communication cable crossing at approximate Station 1700. A CAD site of this size would be able to contain approximately 384,000 cubic yards (cy) of contaminated sediment. In order to develop the first CAD cell, the overburden material from that cell would need to be dredged and disposed of prior to filling operations. Because of phasing considerations, contaminated overburden sediment from the first CAD cell would need to be taken to an off-site upland landfill facility. Some deeper overburden material might be suitable for DMMP unconfined open-water disposal in Elliott Bay. The following considerations were taken into account at the time that this alternative was developed:

- Dredging of 765,000 cy of overburden sediment to create the CAD sites. Of this volume, an estimated 92,000 cy of overburden sediment is anticipated to be unsuitable for open-water disposal and, therefore, would be disposed of at an upland landfill site. The bottom elevation of the required excavation would be at -80.0 feet MLLW. The CAD cell sides would be sloped at 4H:1V (Figure 22). The capacity for contaminated sediment would be 384,000 cy.

- Disposing of suitable overburden at the Elliott Bay open-water disposal site.
- Disposing of approximately 384,000 cy of contaminated sediments within the three disposal cells.
- Covering the CAD site using a minimum of 3 feet of clean cap material.
- The top elevation of the CAD site (including cap) would be at elevation -60.0 feet MLLW to allow for future navigation depth.

The conceptual-level estimate of the total volume required to remove all contaminated sediment in the EW (including a design factor) is approximately 996,000 cy. Therefore, the conceptual EW CAD site capacity would be insufficient to fully contain the EW contaminated sediment volume. In addition, in order to create the CAD cells, all of the overlying sediment in the EW would need to be removed. Therefore, areas within the overall CAD footprint that may not require remediation would still need to be removed in order to accommodate construction of the CAD cells.

4.4.1.1.2 Off-Site Confined Aquatic Disposal

In addition to the on-site CAD option, off-site CAD options have been evaluated as part of the MUDS program and LDW FS. A number of CAD sites have been constructed in Puget Sound, including one constructed in 1984 in the WW (Sumeri 1984 and 1989; USACE 1994). Monitoring data from 1995 of the WW CAD site suggested that the capped contaminated sediment remained effectively isolated (USACE et al. 1999). The CAD site constructed in the WW in 1984 consisted of 1,100 cy of contaminated sediments, with 4,000 cy of cap material placed in the federal navigation channel. The scale of the WW CAD is far less than the capacity required to manage contaminated sediments in the EW. The WW also has a federally authorized navigation channel, like the EW and LDW.

Potential CAD sites have been evaluated in the Duwamish River, WW, and Elliott Bay. A regional MUDS located in Elliott Bay or elsewhere in Puget Sound was considered as part of a programmatic State Environmental Policy Act (SEPA)/National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) conducted by USACE and the Washington State Department of Ecology (Ecology), with DNR and EPA as cooperating agencies (USACE et al. 1999). The EIS evaluated the potential environmental impacts from a wide range of regional sediment MUDS alternatives. Several deep-water sites (150- to 200-foot depths) were conceptually identified in the middle of Elliott Bay. However, all of these lands are owned at least in part by the state and managed by DNR and use of state lands for contaminated sediment disposal would be difficult to achieve. Also, the potential MUDS locations may have overlapped with the Elliott Bay DMMP open-water disposal site boundaries, and construction of a CAD site in very deep water may be technically infeasible.

As part of the LDW FS, a conceptual design was evaluated for construction of two CAD facilities within the LDW. One site is located just south of Harbor Island (RM 0.1 to 0.5; northern site) and the other is located near the Upper Turning Basin (RM 4.4 to 4.8; southern site). The northern site is a deep-water area partially within the authorized navigation channel. Construction of the CAD facilities is estimated to require the removal of 370,000 cy of clean sediment, which is assumed to be disposed at the DMMP open-water disposal site in Elliott Bay. The completed CAD facilities would have a capacity of 310,000 cy of contaminated sediment and require approximately 74,000 cy of capping material. The conceptual CAD design would provide the top of the cap no higher than 3 feet below the federally authorized navigation channel elevation, with a 3H:1V side slope outside of the channel. Based on the conceptual-level volume required to remove all contaminated sediment within the EW (996,000 cy, including a design factor), the LDW CAD capacity would also be insufficient to fully contain the EW contaminated sediment volume and the LDW contaminated sediment would likely have priority for placement in a LDW CAD site, if implemented.

4.4.1.1.3 Implementability

There are significant technical implementability concerns with constructing a CAD site in the EW. Construction sequencing and access to construct a CAD facility within the EW would be difficult due to the high frequency of ship traffic and the significant greater duration needed (due to increased dredge volumes) for dredging of both contaminated sediment and CAD cell overburden material. Navigation impacts would be significant due to the CAD site being located within the federal channel limits. Deep dredging within the EW poses problems for slope stability along the sides of the waterway. New material placed in the CAD cell would have less stability than the existing in situ material, since the placed sediment would be disturbed and unconsolidated, thus increasing risk of slope failures along both sides of the EW where there are existing terminal facilities. To avoid impact on waterway slopes and upland structures, the disposal area footprint would likely need to be confined to within the federal navigation channel limits. Construction of a CAD site could limit future deepening of the EW should navigation requirements increase below the designed top of the CAD site caps. Construction of a CAD site within the EW would also preclude future utility crossings, should the need arise.

Overall, use of an on-site or off-site CAD site is considered to have significant administrative implementability challenges from the standpoints of siting, constructing, and maintaining a CAD facility. Challenges include obtaining agreement from the landowner(s), long-term monitoring and maintenance needs, and enforcing institutional controls on activities above and adjacent to the CAD site (e.g., restricting anchoring and limiting navigation). Land within the EW and surrounding waterbodies may be state-owned and managed by DNR. DNR policy states that it will not allow any contaminated sediment to be placed on state-owned land. A use authorization would also be required with DNR to construct a CAD site on state-owned lands.

4.4.1.1.4 Effectiveness

CAD sites, when properly designed, have been successfully constructed in the Pacific Northwest and nationwide. The technology is considered proven and effective at containing and isolating contaminated sediments in the long-term. However, an on-site CAD facility likely is not capable of handling the estimated volume of contaminated sediment by itself, and additional disposal facility(ies) would need to be used. Short-term effectiveness can be affected by the ability of the responsible party's contractor and/or site conditions to minimize potential loss of contaminated sediments during contaminated sediment filling and capping of the CAD site. Resuspension of contaminated sediments during the construction activities is a major consideration with this disposal alternative, particularly since it would require double-handling (both removal and placement) of the dredged material. Consequently, the placement of the sediment into each CAD cell will require a high degree of control and accuracy.

4.4.1.1.5 Cost

The cost for building a CAD site is anticipated to be moderate to high, with various costs attributed to evaluation, design, permitting and approvals, complicated construction and sequencing, and land acquisition.

4.4.1.1.6 Summary

Due to the difficulties in implementation, the CAD disposal technology will not be retained for further consideration in alternative development in this Screening Memo or in the FS (Table 11). However, a CAD disposal technology may be re-considered during Remedial Design if the adverse implementability considerations change.

4.4.1.2 Nearshore Confined Disposal Facility

A NCDF consists of berms, cofferdams, or similar structures that create a contained disposal area for dredged materials (Figure 24). NCDFs provide for permanent storage of dredged sediments. Containment of contaminated sediments in NCDFs is generally viewed as a cost-effective remedial technology at Superfund sites (EPA 1996). Detailed guidance documents for NCDF construction and management have been developed by USACE and EPA (USACE 1987, 2000; EPA 1994, 1996; Averett et al. 1988; Brannon et al. 1990). NCDFs have been constructed throughout Puget Sound, including in the Milwaukee Waterway in Tacoma, the Eagle Harbor East Operable Unit in Winslow, T-90/91 in Elliott Bay, Pier 1-3 in Everett, and Slip 1 in the Blair Waterway in Tacoma. Within the EW, Slip 27 and Slip 36 have previously been evaluated for the use of this technology. A summary of each evaluation is provided in the sections below.

4.4.1.2.1 Slip 27

As part of the EW Deepening Project in 2000 (Anchor 2000), the option of using Slip 27 as a NCDF was evaluated. This alternative consisted of using the entire capacity of Slip 27 by constructing a containment berm (closure dike) across the mouth of Slip 27. Development of Slip 27 as a NCDF would require demolition of existing Pier 28. Contaminated dredged sediment would then be placed within the confined slip up to elevation +9.0 feet MLLW to keep the contaminated sediment at or below groundwater level which helps to reduce leaching of the contaminants, and a sand cap would be placed to elevation +16.0 feet MLLW.

The following considerations were taken into account at the time that this alternative was originally developed:

- The capacity of the NCDF was estimated to be 250,000 cy.
- The disposal site boundary would not interfere with operations at T-30.
- Minimum encroachment from construction activities would occur at T-25.
- No excavation of the Slip would be implemented to increase the site's capacity.
- Berm construction would include 84,000 cy of select fill, and would be constructed with a temporary notch to allow the passage of barges carrying dredged material.
- A berm foundation treatment would be required for stability (the volume of foundation excavation was estimated to be 15,000 cy).
- A berm armor layer would be required for vessel wake and propeller wash protection (approximately 12,000 cy of armor rock).
- The berm would have a top elevation of +16.0 feet MLLW, top width of 10.0 feet, and 2H:1V side slopes.
- A 7-foot cap would be placed over the dredged sediments (approximately 80,000 cy).

The estimated capacity of Slip 27 would be less than the conceptual total volume of contaminated sediment within EW. Some of the total volume is located within Slip 27, so a NCDF would have the benefit of containing those contaminated sediments in place.

4.4.1.2.2 Slip 36

As part of the EW Deepening Project in 2000 (Anchor 2000), the option of using Slip 36 as a NCDF was evaluated. The Slip 36 NCDF alternative assumed the entire slip would be utilized for filling, and would consist of constructing a containment berm (closure dike) along the EW, placing dredged sediments within the slip up to elevation +9.0 feet MLLW to keep the contaminated sediment at or below groundwater level, which helps to reduce leaching of the contaminants, and placing a sand cap to elevation +16.0 feet MLLW. Development of the Slip 36 NCDF alternative would include demolition of both USCG and Port existing structures including existing timber and concrete piles, timber and concrete apron, and timber fender piles along Pier 36, the Pier 36 apron, and Pier 37. The following design considerations were taken into account at the time that this alternative was developed:

- The dredged sediment capacity of the Slip 36 NCDF was estimated to be 416,000 cy.
- A berm foundation treatment would be required for stability (the volume of foundation excavation was estimated to be 12,000 cy).
- Berm construction would include 95,000 cy of select fill, and would be constructed with a temporary notch to allow the passage of barges carrying dredged material.
- A berm armor layer required for vessel wake and propeller wash protection (approximately 8,000 cy of armor rock).
- The berm would have a top elevation of +16.0 feet MLLW, top width of 10 feet, and side slopes of 2H:1V.
- A 7-foot cap would be placed over the dredged sediments (approximately 124,000 cy).

The estimated capacity of Slip 36 would be less than the conceptual total volume of contaminated sediment within EW. Some of the total volume is located within Slip 36, so a NCDF would have the benefit of containing those contaminated sediments in place.

4.4.1.2.3 Off-Site NCDF Options

Off-site NCDF locations were considered within Elliott Bay as part of the MUDS program, and only one conceptual site using the northern shoreline of T-5 was identified and evaluated. Similar to CAD options evaluated in Elliott Bay, no further evaluations of NCDF options have occurred as part of the MUDS program. However, as part of the EW Deepening Project in 2000 (Anchor 2000), the option of using T-5 as a NCDF was re-evaluated. The footprint of this conceptual NCDF is located within the Lockheed West Superfund Site and consists of construction of a three-sided containment berm extending out from the existing shoreline, placement of the project's dredged sediments unsuitable for open-water disposal, and placement of capping materials. The conceptual design would accommodate a storage capacity of 320,000 cy of unsuitable sediment. The T-5 CDF concept, which was intended to also provide intertidal habitat on the cap surface, was developed based on the following criteria:

- The top of berm and cap elevation would be at –3.0 feet MLLW at the northern end and +5.0 feet MLLW at the southern shoreline. The berm would have side slopes of 2H:1V and a top width at 10.0 feet.
- The footprint of the disposal site would be positioned shoreward of the Outer Harbor Line.
- Armoring is required to prevent scouring of capping material and outer slopes of the containment berm by vessel wakes and wind waves.
- A 6-foot multi-layered cap thickness would be included to provide habitat and armor layers. Temporary wave protection would be provided for the exposed unsuitable sediments during construction.

The estimated capacity of the T-5 NCDF would be less than the conceptual total volume of contaminated sediment within EW, and the design would need to accommodate seismic concerns and future land use.

4.4.1.2.4 Implementability

Technically, using a NCDF as a disposal technology is implementable. Many NCDFs have been constructed in Puget Sound and nationwide. Properly designed, a NCDF has been demonstrated to effectively contain contaminated sediment. Key technical challenges to constructing a NCDF are geotechnical stability and seismic stability of the berm, groundwater transport of leachate, and consolidation/settlement requirements of placed dredged sediment. On-site and off-site conceptual NCDF locations have good access and a NCDF likely could be constructed in those locations.

However, NCDFs face many administrative implementability issues. DNR owns most of the aquatic lands in the EW and has a policy against placing contaminated sediment on Washington aquatic lands. At T-5, the aquatic lands located outside of the Inner Harbor Line are owned by the State of Washington, and those located inside of the Inner Harbor Line are owned by the Port. Of the approximately 14 acres of aquatic land impacted at the T-5 site, the State of Washington owns about 7 acres and the Port owns about 7 acres. DNR approval and a new lease agreement would be required to build the berm on DNR land at T-5. Slip 27 is owned by the Port, and Slip 36 is owned by USCG. An agreement to use either Slip would need to be reached with the Owner. However, the mouths of Slip 27 and Slip 36 are state-owned aquatic land. Therefore, portions of the clean berm material would need to be placed onto DNR land. DNR approval and a new lease agreement would be required to build the NCDF berms on DNR land within the EW.

For Slip 27, another major impediment is a previous agreement developed between the Port and the Muckleshoot Tribe in which the Port agreed to provide a conservation easement that no future pier or moorage improvements will be constructed along the south shoreline of Slip 27 (Muckleshoot Indian Tribe and Port of Seattle 2006). Slip 27 and the remainder of the EW is within the Tribe's U&A Tribal fishing area. The Port also continues to operate Pier 28 and Slip 27 is an actively used berthing slip. Based on these issues, it is unlikely that Slip 27 could be used as a NCDF. In order to use Slip 36 as a NCDF, USCG facilities would need to be relocated and the land acquired from the federal government. In addition, the EW is a Tribal U&A fishing area, including both slips. Creating a NCDF within the EW would impact U&A fishing and approval may be difficult to obtain.

4.4.1.2.5 Effectiveness

Many NCDFs have been successfully constructed in the Pacific Northwest and nationwide, and the technology is considered proven and effective (Port of Tacoma 1992; Hart Crowser 1996; and Boatman and Hotchkiss 1994 and 1997). The identified on-site and off-site NCDFs do not appear to have sufficient capacity to handle all of the contaminated sediment, which would necessitate use of additional disposal technologies.

4.4.1.2.6 Cost

NCDFs are generally considered to be a cost-effective disposal technology at Superfund sites (EPA 1996). The NCDF technology may be considerably more cost-effective if combined with a potential future land use, such as habitat improvement or future container yards.

4.4.1.2.7 Summary

Due to the agreement with the Muckleshoot Tribe, the NCDF disposal technology for Slip 27 has not been retained for further consideration in the development of alternatives (Table 11). Because of federal ownership of Slip 36, and since there are no plans to relocate the USCG facilities, Slip 36 has not been retained for further consideration in the development of alternatives (Table 11). T-5 is also not retained as a disposal technology due to administrative implementability issues. Other potential NCDF locations owned by third parties not discussed in this section will also not be retained for further consideration since no known sites exist, but NCDF disposal may be re-considered in the Remedial Design if some future NCDF site was developed and approved by EPA.

4.4.1.3 Open-Water Disposal

Open-water disposal consists of disposal of sediments at the DMMP unconfined, open-water disposal site in Elliott Bay (Figure 25). This disposal technology would require approval from the DMMP agencies, which include EPA. To be suitable for open-water disposal, sediment must meet screening criteria that is based on chemistry, bioassay, and bioaccumulation testing. It is anticipated that all or nearly all of the sediments required to be removed from the EW because of sediment contamination will not be suitable for open-water disposal. Based on the evaluation conducted in Section 4.3, it is not likely that sediments could be treated to concentrations that are at or below the DMMP disposal criteria. However, a small portion of EW dredge material may satisfy these criteria and be acceptable for open-water disposal.

4.4.1.3.1 Implementability

Open-water disposal is technically implementable, but only applies to sediment that meets DMMP screening criteria, which is generally accepted to be "clean" sediment. Even if some sediment were able to pass DMMP screening and was found to be acceptable for open-water disposal, EPA or stakeholders may have concerns about the perception of disposing of sediment from within a CERCLA site at an open-water disposal site. However, material that was determined to be suitable by DMMP for open-water disposal was disposed of at the Elliott Bay open-water disposal site as part of the EW Phase 1 Removal Action and at the

Commencement Bay open-water disposal site as part of Commencement Bay Superfund cleanup activities.

4.4.1.3.2 Effectiveness

Open-water disposal is an effective disposal technology for "clean" sediment, but not effective for managing contaminated sediment. Open-water disposal receives a low ranking for contaminated sediment (or not applicable ranking).

4.4.1.3.3 Cost

Open-water disposal costs are low relative to all other disposal technologies.

4.4.1.3.4 Summary

Open-water disposal is not retained for detailed analysis in the FS (Table 11). However, open-water disposal may be reconsidered during Remedial Design if there are portions of the EW that are determined to be suitable for DMMP open-water disposal.

4.4.2 Upland Disposal

Dredged sediment can be disposed of off-site at an upland waste disposal facility. Solid waste landfills in the State of Washington are regulated primarily by the Minimum Functional Standards for Solid Waste Handling (WAC 173-304), Criteria for Municipal Solid Waste Landfills (WAC 173-351), and RCRA (Subtitle D). These regulations were established by the State of Washington and the federal government to ensure protection of human health and the environment. Dredged material that is not eligible for open-water disposal and not classified as dangerous waste is categorized as "problem waste" under the minimum functional standards (WAC 173-304-100). In general, sediment that is not suitable for open-water disposal and will pass the Toxicity Characteristic Leaching Procedure (TCLP) test can be disposed of in a solid waste landfill.

An on-site landfill for dewatered contaminated sediments could be constructed within the EW CERCLA OU site boundaries or Harbor Island CERCLA site boundaries since the EW OU is part of the overall Harbor Island CERCLA site. However, Harbor Island and the surrounding upland areas are heavily developed and no site has been identified that could provide adequate capacity for an on-site landfill. Under CERCLA, an on-site landfill would not be required to obtain permits, but would have to meet the substantive requirements for either a Subtitle D or Subtitle C landfill, as described in the following sections.

4.4.2.1.1 Regional RCRA Subtitle D Landfills (Solid Waste)

Dredged material that satisfies the solid waste regulations could be disposed in Subtitle D RCRA commercial landfills. Roosevelt Regional Landfill near Goldendale, Washington, and Columbia Ridge Landfill near Arlington, Oregon, are the two upland regional landfills that have established services to receive wet sediments. These sites are licensed as RCRA Subtitle D commercial landfills in the states in which they operate, and both have the ability to receive wet dredged sediments delivered to the landfill by rail.

One additional landfill, the Greater Wenatchee Regional Landfill in Wenatchee, Washington, requires that the sediment be dewatered so that it will pass the paint filter test for free water prior to accepting the sediment. Disposal at this landfill requires dewatering of sediments for both transport and disposal of the dredged material, which would require a dewatering facility at the point where wet sediments are offloaded from the haul barge to shore.

Allied Waste operates the Roosevelt Regional Landfill. During 2004, Allied Waste (then known as RABANCO) handled dredged material at a barge-to-rail loading facility at T-25. It is anticipated that Allied Waste or other waste handling firms are currently looking for a new waterfront property to provide an offloading facility and subsequent barge-to-rail transloading in the future. Dredged material would be delivered to Allied Waste's sediment offloading facility via barge.

Waste Management operates the Columbia Ridge Landfill. In 2004, Waste Management completed significant upgrades at the landfill to allow offloading of rail cars loaded with soil and dredged material. Waste Management does not currently operate a barge-to-rail transfer facility in the EW area. It is anticipated that Waste Management is currently looking for a new waterfront property to provide an offloading facility and subsequent barge-to-rail transloading in the future.

4.4.2.1.2 RCRA Subtitle C/TSCA Landfills (Hazardous Waste/PCBs)

Material containing PCB concentrations exceeding 50 milligrams per kilogram (mg/kg) dry weight (dw) must be placed in a hazardous waste landfill specially designed and permitted under the Toxic Substances Control Act (TSCA) to receive such materials. Landfills meeting these requirements and effectively providing disposal services for TSCA-regulated solids containing PCBs suitable for landfill disposal and originating in the Northwest include:

- **Chemical Waste Management of the Northwest**: Chemical Waste Management's facility is located at Arlington, Oregon. This Subtitle C secure landfill facility provides land disposal of soil and debris contaminated with PCBs at concentrations exceeding levels allowed in regional solid waste landfills. The Arlington site is accessible from Seattle by rail.
- **U.S. Ecology**: A subsidiary of the American Ecology Corporation, U.S. Ecology operates chemical waste landfills permitted under TSCA for accepting PCB-contaminated materials at Grand View, Idaho, and Beatty, Nevada. The Beatty facility is located 100 miles northwest of Las Vegas. The site at Grand View is accessible by rail.

TSCA regulated solids containing PCBs at concentrations equal to or exceeding 500 mg/kg dw are prohibited from land disposal under TSCA and are typically incinerated; however, existing surface and surface sediment data indicate these concentrations should not be encountered.

4.4.2.1.3 Implementability

Disposal of dredged material in permitted RCRA Subtitle C or RCRA Subtitle D landfills is readily implementable both from a technical and administrative standpoint. Landfill disposal is routinely approved by EPA and the State of Washington for disposal of contaminated sediments.

4.4.2.1.4 Effectiveness

Disposal of dredged material in permitted RCRA Subtitle C or RCRA Subtitle D landfills meets all state and federal requirements and uses reliable and demonstrated technologies.

4.4.2.1.5 Cost

Subtitle D landfill costs are high. Subtitle C landfill costs are significantly higher than Subtitle D landfill costs.

4.4.2.1.6 Summary

Upland landfill disposal is retained for further evaluation.

4.4.3 Beneficial Use

Beneficial use includes in-water and upland placement of dredged material. Aquatic placement includes use of the sediment as capping material, residual management, or habitat creation. Upland beneficial use could potentially include using the untreated or treated sediment as fill, composting it, or blending it with other humic materials and selling it as a commercial soil mixture. The physical properties of the treated material may limit its applicability to some of these potential use options.

4.4.3.1 In-Water Beneficial Use

In Washington State, material not classified as solid waste may be suitable for in-water beneficial use. Under Washington State law, dredged material is defined as a solid waste if it has been designated as unsuitable for open-water disposal (WAC 173-350-040 of the Solid Waste Handling Standards). Dredged sediment would qualify for in-water beneficial use if it meets DMMP criteria for open-water disposal, as well as the SMS criteria.

If an in-water beneficial use of the dredged sediment was located within the EW, no specific permits would be required, other than complying with the substantive requirements of local, state, and federal programs. Beneficial use outside of the EW would require a Clean Water Act (CWA) 404(b)(1) permit from USACE (including Endangered Species Act [ESA] consultation), a CWA 401 Water Quality Certification from Ecology, and a Hydraulic Project

Approval from the Washington Department of Fish and Wildlife (WDFW). Placement of sediment would also require compliance with the state antidegradation policy (WAC 173-204-120). A small portion of EW dredge material potentially may qualify for open-water disposal and comply with the state antidegradation policy and, therefore, beneficial use.

4.4.3.2 Upland Beneficial Use

Oversight of solid waste regulations is assigned to Ecology under the Washington State Solid Waste Management Reduction and Recycling Act (Revised Code of Washington [RCW] 70.95), but under state rule, the county health departments are assigned the permitting and oversight responsibilities. According to the state's Solid Waste Management policy, beneficial use of material must be protective of human health and the environment, and meet the requirements of the antidegradation policy for surface water and groundwater (WAC 173-204-120). King County incorporates the Model Toxics Control Act (MTCA) by reference into its management plans and permit processes for upland beneficial use (WAC 173-340).

Sediment must meet the MTCA Method A Soil Cleanup Levels for unrestricted land use (WAC 173-340-740) to be beneficially used in upland areas in Washington State without restrictions. MTCA Method B would be used to establish treatment standards that would be protective of human health and the environment, including standards protective of wildlife (WAC 173-340-7490 and 7494) and a human health lifetime cancer risk equal to or less than 1 in 1,000,000, and a hazard index equal to or less than 1. In addition, sediment would need to meet the antidegradation policy for surface water and groundwater (WAC 173-204-120). At a minimum, a local county health department permit would be required pursuant to RCW 70.94.1. Similar to in-water beneficial use, a small portion of EW dredge material may qualify for upland beneficial use.

4.4.3.3 Implementability

Beneficial use is technically implementable, but only applies to untreated or treated sediment that is below unrestricted state cleanup levels or open-water disposal criteria, which is generally accepted to be "clean" sediment. In addition, sediment removed from within a CERCLA site is generally not suitable for direct beneficial use applications because of the liability associated with using contaminated material. As a result, the implementability of beneficial use is considered low.

4.4.3.4 Effectiveness

Beneficial use is an effective disposal technology for "clean" sediment, but not effective for managing contaminated sediment (unless combined with a suitable ex situ treatment method). Beneficial use receives a low ranking for contaminated sediment (or not applicable ranking).

4.4.3.5 Cost

Beneficial use costs are low relative to all other disposal technologies.

4.4.3.6 Summary

In-water and upland beneficial use is retained for Remedial Design as a disposal technology for "clean" sediment only, but not carried forward for detailed analysis in the FS.

Table 11
Summary of Screening of Disposal Technologies

GRA	Technology Type	Process Option	Implementability	Effectiveness	Cost	Screening Decision
Disposal	On-site Disposal	CAD	Low	Moderate to High	High	Retained for design, not carried forward for detailed analysis in the FS.
		Slip 27 NCDF	Low	Moderate to High	High	Retained for design, not carried forward for detailed analysis in the FS.
		Slip 36 NCDF	Low	Moderate to High	High	Not carried forward for detailed analysis in the FS.
	Off-site Disposal	T-5 NCDF	Low	Moderate to High	High	Retained for design, not carried forward for detailed analysis in the FS.

Table 11
Summary of Screening of Disposal Technologies

GRA	Technology Type	Process Option	Implementability	Effectiveness	Cost	Screening Decision
		Upland Landfill	High	High	High	Retained
		Open-Water Disposal	Low	Low	Low	Retained for design, not carried forward for detailed analysis in the FS.
		Beneficial Use	Low	Low	Low	Retained for design, not carried forward for detailed analysis in the FS.

4.5 Summary of Retained Remedial and Disposal Technologies

A comprehensive summary of the screening of remedial and disposal technologies for the EW is provided in Table 12. This table combines the information provided in the preceding sections to provide an overall comprehensive view of the analysis.

In order to help combine various remedial technologies into remedial alternatives, the critical site restriction information presented in Section 4.2 and Table 3 are integrated with the retained remedial technologies and presented in Table 13. This table summarizes where each retained technology is applicable by CMA. For those technologies not deemed to be applicable in a specific CMA, a brief summary is provided that describes the rationale for not retaining the technology in that CMA. Further evaluation of technology applicability to the site CMAs will also be performed in the FS.

Table 12
Summary of Screening of Remedial Technologies

GRA	Technology Type	Process Options	Implement-ability	Effectiveness	Cost	Screening Decision
No Action	NA	NA	High	Low	Low	Retained
Institutional Controls	NA	NA	Moderate	Low	Low	Retained
Monitored Natural Recovery	NA	Sedimentation	High	Moderate	Low	Retained
Enhanced Natural Recovery	NA	Thin-layer placement of clean sediment	High	Moderate	Low to Moderate	Retained
In situ Containment	Capping	Conventional Cap	Moderate	High	Moderate	Retained
		Low Permeability Cap	Low	High	Moderate to High	Not Retained
		Reactive Cap	Low	High	Moderate to High	Retained
Removal	Dry Excavation	Soil Excavators	Low	Moderate to High	High	Retained (in limited areas)
	Dredging	Mechanical Dredging	Moderate to High	Moderate to High	High	Retained
		Hydraulic Dredging	Low in Open-water Areas; Low to Moderate in Underpier Areas	Moderate to High	High	Retained for Underpier Areas; Not Retained Elsewhere
In situ Treatment	Physical-Immobilization	Amendments (e.g., Granulated Activated Carbon and organoclays)	High	Moderate to High	Moderate to High	Retained
		Stabilization	Not retained. Refer to Section 4.3.7.1 and Lower Duwamish Waterway Candidate Cleanup Technologies (RETEC 2005)			
		Electro-chemical Oxidation				
		Vitrification				
		Ground Freezing				
	Biological	Slurry Biodegradation				
		Aerobic Biodegradation				
		Anaerobic Biodegradation				
		Imbiber Beads				
	Chemical	Slurry Oxidation				
		Oxidation				
	Physical-Extractive Processes	Oxidation				
		Sediment Flushing				
Ex situ Treatment	Physical/ Chemical	Acid Extraction	Not retained. Refer to Section 4.3.7.2 and Lower Duwamish Waterway Candidate Cleanup Technologies (RETEC 2005)			
		Solvent Extraction				
		Slurry Oxidation				
		Reduction/Oxidation				
		Dehalogenation				
		Sediment Washing				
		Radiolytic Detoxification				
	Biological	Enhanced Bioremediation				
		Slurry-phase Biological Treatment				
		Fungal Biodegradation				
		Landfarming/ Composting				
		Biopiles				
	Physical	Separation	Retained			
		Solar Detoxification	Not retained. Refer to Section 4.3.7.2 and Lower Duwamish Waterway Candidate Cleanup Technologies (RETEC 2005)			
		Solidification				
	Thermal	Incineration				
		High-temperature Thermal Desorption (HTTD)				
		Low-temperature Thermal Desorption (LTTD)				
		Pryolysis				
		Vitrification				
		High-pressure Oxidation				

Note: * - Dependent upon detailed natural recovery in FS.

Table 13

Applicability of Retained Cleanup Technologies to EW Construction Management Areas for Assembly of Combination-Technology Remedial Alternatives

	General Response Actions[1, 2] and Cleanup Technologies								
	No Action (NA)	Institutional Controls (ICs)[3]	Natural Recovery		In situ Containment	Removal		In situ Treatment	
Construction Management Areas (CMAs)	None	Administrative and Legal Controls	Monitored Natural Recovery (MNR)[4]	Enhanced Natural Recovery (ENR)[5]	Capping[6]	Dredging[7]	Dry Excavation[8]	Physical Immobilization[5, 9]	Notes
Junction Reach	X	X	X	X	X	X	X	X	• All retained remedial technologies are considered applicable.
Sill Reach	X	X	X	X	X	X	X	X	• ENR and Physical Immobilization are applicable technologies assuming specialty placement equipment can access the area. • Capping is retained for a portion of the Sill Reach, but is not technically implementable in all areas due to equipment access issues beneath existing bridge structures. • Dredging is retained for a portion of the Sill Reach, but is not technically implementable in all areas due to equipment inaccessibility, and need to avoid impacts to critical infrastructure. • Dry Excavation is retained for a portion of the Sill Reach, but is not implementable in all areas due to equipment inaccessibility in this area.
Shallow Main Body – Stations 6200 to 6850	X	X	X	X	X	X	X	X	• Capping is an applicable technology except in the underpier area of the timber wharf where cap placement may result in adverse structural impacts to the wharf. • Dredging is an applicable technology but may require structural improvements to the existing concrete bulkhead and timber wharf.
Former Pier 24 Piling Field	X	X	X	X	X	X	X	X	• Dredging is an applicable technology assuming the existing timber piling and bulkhead are removed, and that the shoreline slope can be laid back to a flatter grade.
Shallow Main Body – Stations 5700 to 6200	X	X	X	X	X	X		X	• Dry Excavation is not applicable as it is not a shoreline area.
Underpier Areas	X	X		X		X		X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not technically implementable due to equipment access restrictions, and is not administratively implementable due to potential structural damage that may occur following placement of the cap. • Dredging is an applicable technology but will require use of specialty diver-assisted dredging equipment and is not capable of removing all contaminated sediment due to equipment inability to remove interstitial and interbedded sediment. • Dry Excavation is not applicable due to equipment inaccessibility in this area.
Berth Areas	X	X		X	X	X		X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not administratively implementable as a stand-alone technology due to berthing elevation requirements, but is applicable if implemented in conjunction with Dredging. • Dredging is applicable assuming structural improvements are constructed to maintain stability of shoreline slopes and structures (see limitations presented in Table 3) and/or dredging setbacks are established. • Dredging may also require placement of backfill material to help maintain slope and structure stability. • Dry Excavation is not applicable as they are not part of a shoreline area.

Table 13

Applicability of Retained Cleanup Technologies to EW Construction Management Areas for Assembly of Combination-Technology Remedial Alternatives

Construction Management Areas (CMAs)	General Response Actions[1, 2] and Cleanup Technologies								Notes
	No Action (NA)	Institutional Controls (ICs)[3]	Natural Recovery		In situ Containment	Removal		In situ Treatment	
	None	Administrative and Legal Controls	Monitored Natural Recovery (MNR)[4]	Enhanced Natural Recovery (ENR)[5]	Capping[6]	Dredging[7]	Dry Excavation[8]	Physical Immobilization[5, 9]	
Slip 27 Channel/ Pier 28	X	X	X	X	X	X		X	• MNR may be effective in some areas of the Slip 27 channel; however, it may not be effective in all areas due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not administratively implementable as a stand-alone technology due to berthing elevation requirements, but is applicable if implemented in conjunction with Dredging. • Dredging is implementable, assuming structural improvements are made to Pier 28 and Slip 27 bridge infrastructure, and/or dredging setbacks are established. • Dry Excavation is not applicable as it is not a shoreline area.
Slip 36/ T-46 Offshore	X	X		X	X	X		X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is an applicable technology except adjacent to the structures where cap placement may result in adverse structural impacts. • Capping is not administratively implementable as a stand-alone technology due to berthing elevation requirements, but is applicable if implemented in conjunction with Dredging. • Dredging is implementable assuming structural improvements are made to existing piers within Slip 36 and/or dredging setbacks are established. • Dry Excavation is not applicable as it is not a shoreline area.
Mound Area/ Slip 27 Shoreline	X	X		X	X	X	X	X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not administratively implementable as a stand-alone technology due to encroachment of the cap into the Federal Navigation Channel CMA, but is applicable if implemented in conjunction with Dredging. • Dredging is applicable but may require installation of retaining walls at the top of slope or lay-back of the top of slope to accommodate the dredging.
T-30/ USCG Nearshore	X	X		X	X	X	X	X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not administratively implementable as a stand-alone technology due to encroachment of the cap into the Federal Navigation Channel, but is applicable if implemented in conjunction with Dredging. • Dredging is applicable; however, repair (or demolition) of existing over-water piers in this area may need to be completed prior to start of dredging activities.
Communication Cable Crossing	X	X		X	X	X		X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not administratively implementable as a stand-alone technology due to navigation elevation requirements, but is applicable if implemented in conjunction with Dredging. • Dredging is applicable but will be limited due to presence of the cable and armored trench. • Dry Excavation is not applicable as it is not a shoreline area.

Table 13

Applicability of Retained Cleanup Technologies to EW Construction Management Areas for Assembly of Combination-Technology Remedial Alternatives

Construction Management Areas (CMAs)	General Response Actions[1, 2] and Cleanup Technologies								Notes
	No Action (NA)	Institutional Controls (ICs)[3]	Natural Recovery		In situ Containment	Removal		In situ Treatment	
	None	Administrative and Legal Controls	Monitored Natural Recovery (MNR)[4]	Enhanced Natural Recovery (ENR)[5]	Capping[6]	Dredging[7]	Dry Excavation[8]	Physical Immobilization[5, 9]	
Federal Navigation Channel	X	X		X	X	X		X	• MNR is not administratively implementable as it will not be effective due to vessel propwash and other operational uses that generate an erosional environment. • Capping is not administratively implementable as a stand-alone technology due to navigation elevation requirements, but is applicable if implemented in conjunction with Dredging. • Dry Excavation is not applicable as it is not a shoreline area.

Notes:

1) Disposal technologies are not presented on this table as off-site landfill disposal is the only retained technology and process option for contaminated sediment that will be removed from the EW.
2) Ex situ treatment technologies are not retained for this Screening Memo per the rationale provided in the Lower Duwamish Waterway Candidate Technical Memorandum (RETEC 2005).
3) Institutional controls include administrative and legal controls that may be required in conjunction with implementation of remedial action. Institutional controls are considered to be applicable to all CMAs, and will be evaluated in detail during development of the Feasibility Study.
4) MNR is assumed to be feasible and effective in portions of the EW for which preliminary results from the Draft STER (Anchor QEA and Coast and Harbor 2011) indicate are experiencing net deposition without experiencing significant mixing from erosive forces. Detailed evaluation of natural recovery and recontamination will be evaluated for the entire waterway in the FS.
5) The ENR and Physical Immobilization remedial technologies assume that ENR and amendment materials will be stable on shoreline slopes, and that sediment mixing due to erosional forces will not result in recontamination of other CMAs.
6) The Capping remedial technology is retained for an engineered/conventional sand cap process option for the purposes of this Screening Memo.
7) The Dredging remedial technology is retained for mechanical dredging and specialty (i.e., diver-assisted) dredging for the purposes of this Screening Memo. The Dredging remedial technology assumes that residuals management cover material will be placed in all dredged areas within the EW, and must consider overall slope stability and/or slope improvements in all areas where it is implemented.
8) The Dry Excavation remedial technology is only applicable within shoreline CMAs where upland equipment can excavate bank sediment during periods of low tide.
9) The Physical Immobilization technology is the only in situ treatment retained and is applied as placement of amendments for the purposes of this Screening Memo.

5 IDENTIFICATION AND SCREENING OF SITE-SPECIFIC REMEDIAL ALTERNATIVES

This section identifies and provides a preliminary screening of site-specific remedial alternatives for the EW OU. Preliminary site-specific remedial alternatives are identified early in the SRI/FS process in order to focus detailed development and evaluation of appropriate remedial alternatives in the FS. The alternatives identified in this section are not intended to be the only or final alternatives that will be evaluated as part of the FS; the FS will further develop, and conduct a detailed evaluation of, the remedial alternatives that are retained as part of this screening evaluation.

This section presents a preliminary set of single technology and combination technology remedial alternatives for the EW OU that implement the remedial technologies retained in Section 4 for application in the individual CMAs. The objectives of this preliminary screening of alternatives are as follows:

- Identify single-technology alternatives against screening level evaluation criteria to assess whether any single-technology complies with the evaluation criteria and should be retained for detailed evaluation in the FS, and identify potential limitations of using each single-technology alternative to inform use in combined technology alternatives in the FS.
- Identify a combination-technology alternative that is anticipated to comply with the screening level evaluation criteria, and provide preliminary evaluation of this alternative, and identify potential limitations to inform assembly and evaluation of combined technology alternatives in the FS.

Six alternatives have been developed for consideration as part of this preliminary identification and screening evaluation for the EW OU. Five of the alternatives represent implementation of a single-technology remediation approach for the entire site, and one alternative is assembled by combining one or more of the retained technologies deemed applicable within each individual CMA, as described in Section 4 (see Table 13). The combination-technology alternative includes a range of remediation technologies for implementation in different portions of the site, including natural recovery processes, in situ capping and treatment, and removal and off-site upland landfill disposal of contaminated sediments and debris.

As discussed in Section 3, PRGs and RALs were not developed for this Screening Memo, but will be developed in the FS. To serve as a surrogate for RALs, both single-technology and combination-technology alternatives identify specific remediation areas based on surface sediment exceedances of SMS in EW sediments. Although additional contaminants not included in the SMS are likely to be included in the FS, the contaminants included in the SMS are expected to provide an adequate measure of sediments requiring remediation for screening alternatives in this Screening Memo. The combination-technology alternative is evaluated using SQS as surrogate RALs to delineate areas of the site that require implementation of a general response action, based on surface sediment contamination shown on the polygons in Figure 6.

The following sections provide a brief description of the preliminary single-technology and combination-technology remedial alternatives, discuss criteria used to complete the preliminary alternative evaluations, and summarize remedial alternatives that will be carried forward for detailed evaluation in the FS.

5.1 Description of Preliminary Remedial Alternatives

This section provides a brief summary of the single-technology and combination-technology remedial alternatives assembled for evaluation in this Screening Memo. The following retained single-technology and combination-technology alternatives are included in this evaluation:

- No Action
- Monitored Natural Recovery in all Areas Exceeding SQS Criteria
- Enhanced Natural Recovery in All Areas Exceeding SQS Criteria
- Cap All Areas Exceeding SQS Criteria
- Dredge All Areas Exceeding SQS Criteria with Upland Disposal
- Combination Technologies by Construction Management Area

The application of amendments (such as GAC and organoclays) has not been included in any single-technology alternative for evaluation in this Screening Memo. This is due in part because amendments can be used to enhance ENR or capping technologies by reducing bioavailability of contaminants, but is not assumed to significantly differ from the assessment of ENR or cap all area alternatives to warrant an additional single technology alternative. The use of amendments have been included in certain areas of the EW for evaluation as part of the Combination Technologies by Construction Management Area alternative.

The preliminary remedial alternatives have been developed assuming that no structure repair and/or replacement will be necessary to implement the remedy, with the exception of the "Dredge All Areas Exceeding the SQS Criteria with Upland Disposal" alternative. Additional cost has been incorporated in the estimate for implementation of the "Dredge All Areas Exceeding the SQS Criteria with Upland Disposal" alternative as structural improvements/replacements would be necessary to prevent structural and/or slope failure during removal of all sediment that exceeds the SQS criteria.

This section describes each remedial alternative. Preliminary evaluation criteria described in Section 5.2 are used to screen each of these remedial alternatives in Section 5.3.

5.1.1 Common Elements

The remedial alternatives considered in this Screening Memo are generally different in description and scope; however, there are some comment elements that exist between one or multiple alternatives. The following common elements are not considered in detail for the preliminary evaluation of remedial alternatives, but will be addressed in detail during development of the FS:

- **Institutional Controls**. Institutional controls are assumed to be required, to varying degrees, for each alternative presented in this Screening Memo and may include fish consumption advisories, waterway-use restrictions, and long-term property deed limitations. These institutional controls are designed to assist the proposed remedial alternative in meeting RAO requirements where implementation of individual remedial technologies may not be sufficient. The need for institutional controls is broadly considered as part of the implementability evaluation in Section 5.3; however, costs associated with implementation of institutional controls are assumed to be constant between each of the preliminary remedial alternatives.

- **Remedial Action Levels.** As discussed above, PRGs and RALs will be developed in the FS. Therefore, for this Screening Memo, the SQS will be used as surrogate RALs for comparison to EW surface sediment concentrations in the single-technology and combination-technology alternatives.
- **Disposal of Contaminated Sediment and Debris.** For each alternative that considers dredging/removal of contaminated material, it is assumed that these materials will be transloaded to the uplands for disposal at a permitted and licensed upland disposal facility (i.e., landfill) since only off-site upland landfill disposal was retained as a disposal technology in Section 4. There is no current transload facility that is operational near the EW OU; however, the preliminary remedial alternative cost estimates assume that a nearby transload facility will be available at the time of construction.
- **In-Water Work Windows.** Construction activities at the EW OU are limited to specific timeframes that are established based upon environmental and regulatory factors. For the purposes of this alternative evaluation, it is assumed that all work will be performed within the allowable in-water work windows; and, the alternative cost estimates take into account effort for multiple mobilizations if work is to be performed during multiple in-water work windows.
- **Natural Recovery Processes.** The feasibility and timeframes for meeting surrogate RALs using natural recovery processes will be evaluated and estimated in the FS. Therefore, the long-term effectiveness of MNR and ENR in various areas of the EW will be fully evaluated as part of the FS. For the purpose of this Screening Memo, both MNR and ENR are assumed to be feasible and effective in portions of the EW that preliminary results from the Draft STER (Anchor QEA and Coast and Harbor 2011) indicate are experiencing net deposition without experiencing significant mixing from erosive forces.
- **Cost Estimates.** The FS will develop remedial action costs to an accuracy of -30% to +50%. The costs presented herein are conceptual in nature and intended to provide a relative comparison for screening purposes, but detailed cost estimates are not provided for in this Screening Memo. EWG will refine and revise cost assumptions during the FS process.
- **Effectiveness.** Long-term effectiveness is evaluated in a qualitative manner as a means of assessing reduction of risks for each remedial alternative. Although no quantitative

evaluation of long-term effectiveness will be conducted for the Screening Memo, a quantitative evaluation of baseline and post-remedy conditions will be conducted in the FS once detailed remedial alternatives are developed. The FS evaluation is expected to include estimates of the SWAC of key contaminants to serve as a relative comparison between remedial alternatives.

- **Cap Erosion Protection**. Any remedial alternative involving capping will require consideration of an armoring component, if site-specific analyses suggest that there is a potential for scour as a result of either propeller wash or high-flow events. The assumptions for cap armor included in this Screening Memo are based on existing information presented in the Draft STER (Anchor QEA and Coast and Harbor 2011) and are subject to further evaluation during the FS.

5.1.2 Alternative A – No Action

EPA guidance requires that the No Action alternative be considered at all sites where an FS is being performed. The No Action alternative should reflect the site conditions described in the baseline HHRA and ERA and the SRI. Under this alternative, the No Action remedial technology will be implemented in all CMAs shown on Figure 9.

5.1.3 Alternative B – Monitored Natural Recovery in All Areas Exceeding SQS Criteria

Alternative B is a single-technology alternative that includes implementation of the MNR remedial technology within all areas of the EW OU where surface sediments exceed the SQS (surrogate RALs) for all SMS parameters, as shown on Figure 27 and described in Table 14. This alternative assumes that portions of the site that experience net deposition without experiencing significant mixing from erosive forces, will recover and meet the surrogate RALs in an acceptable timeframe.

Cost for implementation of Alternative B is associated with long-term monitoring that will be required to determine compliance with cleanup criteria. Contingency plans may need to be developed to address compliance actions if the remedy cannot demonstrate natural recovery within an acceptable timeframe.

Significant institutional controls, such as proprietary controls and informational devices, likely needs to be implemented in conjunction with conducting regular monitoring of surface sediments throughout the site in order to document the success of the MNR technology in the EW.

Table 14
Summary of Alternative B – Monitored Natural Recovery in All Areas Exceeding SQS Criteria

GRA	Technology Type	Process Options	Area of Application (acres)	Volume (cubic yards)
Monitored Natural Recovery	NA	Sedimentation	129.0	NA

5.1.4 Alternative C – Enhanced Natural Recovery in All Areas Exceeding SQS Criteria

Alternative C is a single-technology alternative that includes placement of ENR material (clean sand) within all areas of the EW OU that exceed surface sediment detected concentrations of the SQS (surrogate RALs) for SMS parameters, as shown on Figure 28 and described in Table 15. Areas that have surface sediment concentrations below the surrogate RALs are assigned the No Action remedial technology for this alternative.

Alternative C involves placement of clean sand (for this Screening Memo, ENR is assumed to be a nominal 9-inch-thick layer of clean sand) over the SQS exceedance polygons shown on Figure 6, resulting in a total ENR placement area of approximately 129 acres. Placement of the ENR material in the berth and navigation channel areas assumes no impact to berthing and navigation activities. However, a detailed analysis of impacts to these activities would need to be conducted prior to assigning ENR to a specific CMA.

Cost for implementation of Alternative C includes mobilization of construction equipment to the EW OU, completion of surveys and construction monitoring activities, procurement and placement of the ENR material, and long-term monitoring that will be required to verify that the remedy meets the requirements of the surrogate RALs. Significant institutional controls, such as proprietary controls and informational devices, likely needs to be implemented in conjunction with conducting regular monitoring of surface sediments throughout the site to document the success of the ENR technology in the EW.

Table 15

Summary of Alternative C – Enhanced Natural Recovery in All Areas Exceeding SQS Criteria

GRA	Technology Type	Process Options	Area of Application (acres)	Total Volume (cubic yards)
Enhanced Natural Recovery	NA	Thin Layer Placement of Clean Sediment	129.0	157,000 [1]

Notes:

1. Total ENR volume includes placement of approximately 122,000 cy of material in open-water areas and 35,000 cy of material in underpier and difficult access areas.

5.1.5 Alternative D – Cap All Areas Exceeding SQS Criteria

Alternative D is a single-technology alternative that includes capping all open-water areas within the areas of the EW that exceed surface sediment detected concentrations of the SQS (surrogate RALs) for all SMS parameters, as shown on Figure 29 and described in Table 16. Areas that have surface sediment concentrations below the surrogate RALs or that are located beneath existing structures (e.g., piers and bridges), are assigned the No Action remedial technology for this alternative.

Alternative D involves placement of an engineered cap (conceptually 4 feet in thickness that includes a contaminant isolation layer, filter layer, and armor layer) over the SQS exceedance areas shown on Figure 6, resulting in a total site capping area of approximately 102 acres. The total capping area is less than the area identified in Alternatives B and C since cap placement for this alternative is not assumed to occur in Underpier Area CMAs as implementation of the capping technology in these CMAs is not technically implementable (see Section 4.3.5). Cap placement in the Sill Reach CMA may be restricted due to shallow water depths and limited equipment access. Additionally, placement of the engineered cap under this alternative is proposed in berth and navigation channel areas, and does not take into consideration preservation of berthing and navigation channel elevations, which are currently defined as waterway use requirements. Dredging is not proposed to be completed as part of this single-technology remedial alternative and, therefore, the implementability of this alternative would consider deauthorization of the Federal Navigation Channel in areas of the site where placement of an engineered cap does not meet required navigation elevations. Additional details regarding the technical and administrative implementability of this capping alternative is provided in Sections 4.3.5 and 5.3.

Cost for implementation of Alternative D includes mobilization of construction equipment to the EW OU, completion of survey and construction monitoring activities, procurement and placement of the capping material, and long-term monitoring that will be required to verify that the remedy meets the requirements of the surrogate RALs. Institutional controls, such as proprietary controls and informational devices, likely needs to be implemented in conjunction with conducting regular monitoring of surface sediments throughout the site in order to document the success of the Capping technology in the EW.

Table 16
Summary of Alternative D – Cap All Areas Exceeding SQS Criteria

GRA	Technology Type	Process Options	Area of Application (acres)	Total Volume (cubic yards)
In situ Containment	Capping	Conventional Cap	102.0	824,000 [1]

Notes:
1. Total cap volume includes placement of approximately 412,000 cy of attenuation material, 165,000 cy of filter material, and 248,000 cy of armor material.

5.1.6 Alternative E – Dredge All Areas Exceeding the SQS Criteria with Upland Disposal

Alternative E is a single-technology alternative that includes dredging all surface and subsurface contaminated sediment within the EW OU with detected concentrations above the SQS (surrogate RALs) for all SMS parameters, as shown on Figures 7 and 30, and described in Table 17. This alternative assumes all dredged material will be transferred to the uplands at a readily-available transload facility and disposed in an existing landfill facility. Structural limitations for dredging adjacent to existing piers, bulkheads, and other structures are acknowledged for this alternative (Table 3) and discussed in more detail in Section 5.3.

Alternative E includes dredging approximately 996,000 cy of contaminated sediment from 176 acres within the EW OU for off-site disposal. This volume is based on the "clean" neatline surface created using IDW (e.g., volume of all sediment exceeding SQS criteria), as described in Section 2.3.3 and shown in Figure 6. This volume also includes a 50% increase for the following design factors:

- Allowable overdredge, which is a common contracting approach that accounts for overdredging associated with operational characteristics of dredging equipment
- An allowance to account for additional sediment characterization during design (i.e., presence of contaminants below the presently estimated depth of contamination)
- An allowance to account for cleanup passes for residuals management
- Additional volumes required for constructability of dredge prisms, such as stable side slopes

This adjustment for estimating preliminary dredge volumes is consistent with literature evaluations of previous FS volume estimates and actual removal volumes for large sediment remediation sites (Palermo 2009). Conceptual dredge cuts range from less than 1 foot to approximately 10 feet.

Mechanical dredging is anticipated to be used for the majority of the EW, except for Underpier Area CMAs, which will require the use of specialty dredging techniques to remove accumulated sediment above the existing armored slopes, as shown on Figure 11 (Terminal 18) and Figure 12 (Terminals 25 and 30). This alternative assumes that removal of the existing armored slopes will not be conducted. This remedial alternative assumes that following completion of dredging activities, a nominal 6-inch residuals management cover layer, made up of clean sand, will be placed in all dredged areas in order to address any dredge residuals that may remain.

Cost for implementation of Alternative E includes mobilization of construction equipment to the EW OU, completion of surveys and construction monitoring activities, mechanical dredging in open-water areas and specialty dredging in underpier areas and disposal of contaminated sediment at an upland landfill facility, placement of residuals management cover materials, and post-construction monitoring to verify that the remedy meets the surrogate RALs. Additionally, conceptual-level costs are included in this remedy for anticipated structural repair and/or replacement to EW structures (i.e., piers, bulkheads, and bridges) that would be required to implement Alternative E.

Institutional controls, such as proprietary controls and informational devices, likely needs to be implemented in conjunction with conducting regular monitoring of surface sediments throughout the site in order to document the success of the dredging technology in the EW.

Table 17
Summary of Alternative E – Dredge All Areas Exceeding the SQS Criteria with Upland Disposal

GRA	Technology Type	Process Options	Area of Application (acres)	Total Volume (cubic yards)
Removal	Dredging	Mechanical Dredging	137.3	913,000 [1]
Removal	Dredging	Underpier Dredging	38.3	84,000 [1]

Notes:
1. Implementation of the dredging technology also includes placement of approximately 110,000 cy of residuals management cover material in the open-water site areas, and approximately 33,000 cy of residuals management cover material in the underpier areas.

5.1.7 Alternative F – Combination Technologies by Construction Management Area

Alternative F is a combination-technology alternative that is assembled to represent implementation of specific remedial technologies within specific CMAs, based on the technology screening process described in Section 4 and the surface sediment concentrations in relation to the SMS SQS criteria (surrogate RALs) shown on Figure 6. The purpose of developing a combination-technology alternative is to identify a reasonable combination of technologies that are anticipated to meet the surrogate RALs, but also balances implementability, effectiveness, and cost when applied to each CMA. The combination-technology alternative in the Screening Memo also identifies potential limitations to inform assembly and evaluation of combined technology alternatives in the Feasibility Study.

Alternative F is evaluated in Section 5.3 based on the use of the SQS as surrogate RALs to evaluate effectiveness of the alternative as a function of cost. Remedial actions under this alternative will only be applied to those polygons where detected surface sediment concentrations exceed the SQS surrogate RALs for Alternative F (Figure 6). The SQS used as surrogate RALs for this alternative, is considered an acceptable criteria that maximizes the remediation of contaminated sediment. All other areas that are below the surrogate RALs will be assigned No Action. Alternative F is expected to be indicative of one type of combination-technology alternative that will be assembled and evaluated during development of the detailed FS.

The proposed combination-technology scope for implementation of Alternative F is shown on Figure 31, and is described as follows:

- ENR is assigned to the Junction Reach, Sill Reach, Shallow Main Body – Stations 6200 to 6850, and Shallow Main Body – Stations 5700 to 6200 CMAs, and will be applied in polygons where detected surface sediment concentrations exceed the SQS surrogate RALs. Following further natural recovery evaluations to be completed in the detailed FS, the MNR technology will be considered for implementation in the Shallow Main Body – Stations 5700 to 6200 CMA for this alternative.
- In situ Treatment (assumed to be application of amendments) and ENR are assigned to all Underpier Area CMAs of the EW OU. In situ treatment and ENR will be applied as a combined remedial technology to all underpier areas where detected surface sediment concentrations exceed the SQS surrogate RALs. For the purposes of this Screening Memo, 60% of the underpier areas were assigned ENR, and 40% of the underpier areas were assigned in situ treatment.
- The capping remedial technology will be applied to the Former Pier 24 Piling Field CMA. Capping will include placement of an engineered cap (4-foot thickness) in polygons where detected surface sediment concentrations exceed the SQS surrogate RALs.
- The Dredging and Capping remedial technologies will be applied to the Mound Area/Slip 27 Shoreline, T-30/USCG Nearshore, Slip 27 Channel, and Communication Cable Crossing CMA in order to allow for removal of a portion of the contaminated sediment and placement of the engineered cap. Implementation of the dredging plus capping technologies will be designed so that the final cap surface will meet Federal Navigation Channel clearance requirements, as shown on Figure 26. These technologies will be applied to polygons where detected surface sediment

concentrations exceed the SQS surrogate RALs.

- The Dredging and Backfill/Capping remedial technologies will be applied to the berth areas (T-18, T-25, and T-30) of the EW OU using the following guidelines:
  - Dredging will be completed to remove surface and subsurface contamination in polygons where detected surface sediment concentrations exceed the SQS surrogate RALs. An adequate volume of subsurface sediments will subsequently be removed to also meet the SQS surrogate RALs.
  - In polygons where dredging removes all SQS contamination and the dredge cut is less than 4 feet in thickness, the polygon will be backfilled to the pre-dredge elevation.
  - In polygons where removal of all SQS contamination requires a dredge cut of 4 feet or more in thickness, the polygon will be dredged to a thickness of 4 feet and then an engineered cap will be placed.
  - Dredge cuts in these berth areas will require site-specific assessment of structural stability; however, it is assumed (for the purposes of this Screening Memo) that structural repair and/or replacement will not be necessary for implementation of Alternative F.
- The Dredging with Residuals Management Cover remedial technology is assigned to the Federal Navigation Channel and Slip 36/T-46 Offshore CMAs. Dredging with Residuals Management Cover involves removal of contaminated sediment to the SQS surrogate RALs, followed by placement of a nominal 6-inch layer of residuals management cover material to address remaining residuals surface contamination. This technology will be applied in the polygons where detected surface sediment concentrations exceed the SQS surrogate RALs. The Dredging with Residuals Management Cover remedial technology will not be applied in the polygons where surface sediment concentrations are below the SQS, as existing conditions within the navigation channel are acceptable for ongoing operational use of the waterway. Therefore, Alternative F does not propose leaving behind contaminated subsurface sediments that will require dredging as part of future channel maintenance activities.

The Port and USACE do not have current plans to conduct navigational dredging within the EW OU. The previous dredging events described in the Screening Memo have provided sufficient depth to meet current Port and tenant navigation and berthing needs in the foreseeable future. Limited future maintenance dredging may be required, though the timeframe and areas requiring dredging are unknown. However, due to the relatively low predicted sedimentation rates within the EW, regular maintenance dredging is expected to be needed infrequently.

Cost for implementation of Alternative F includes mobilization of construction equipment to the EW OU, completion of surveys and construction monitoring activities, procurement and placement of ENR and amendment materials, mechanical dredging and disposal of contaminated sediment at an upland landfill facility, placement of residuals management cover and backfill materials, procurement and placement of capping materials and post-construction monitoring to verify that the remedy meets the surrogate RALs. Additionally, implementation of institutional controls, including proprietary controls and informational devices, likely needs to be required to ensure long-term compliance with these alternatives.

Construction elements, including acreage and volumes for Alternative F are summarized in Table 18.

Table 18
Summary of Alternative F – Combination Technologies by Construction Management Area

GRA	Technology Type	Process Options	Area of Application (acres)	Total Volume (cubic yards)
Enhanced Natural Recovery	NA	Thin Layer Placement of Clean Sediment	25.7	32,000 [1]
In situ Treatment	Physical Immobilization	Granulated Activated Carbon (GAC)	8.6	7,000
Removal	Dredging	Mechanical Dredging	93.6	744,000 [2]
In situ Containment	Capping	Conventional Cap	22.3	180,000 [3]

Notes:
1. Total ENR volume includes placement of approximately 7,000 cy of material in open-water areas and 25,000 cy of material in underpier and difficult access areas.

2. Implementation of the dredging technology also includes placement of approximately 42,000 cy of residuals management cover material in the open-water site areas and approximately 52,000 cy of backfill material in the berth areas.
3. Total cap volume includes placement of approximately 90,000 cy of attenuation material, 36,000 cy of filter material, and 54,000 cy of armor material.

5.2 Evaluation Criteria

EPA guidance (EPA 1988) requires that the preliminary screening of alternatives include criteria for evaluation of implementability, effectiveness, and cost. The retained list of remedial alternatives (following the evaluation in this Screening Memo), and additional alternatives assembled during development of the FS, will be subject to a detailed analysis using the following nine CERCLA evaluation criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Short-term effectiveness
- Reduction of contaminant toxicity, mobility, and volume through treatment
- Implementability
- Cost
- State acceptance
- Community acceptance

Each single-technology and combination-technology alternative is evaluated against the preliminary evaluation criteria in Section 4.1. In order to provide a relative cost comparison between the different remedial alternatives, the conceptual-level remediation costs in this Screening Memo include only remedial construction costs and long-term monitoring costs, but do not include pre-construction costs (e.g., engineering design and permitting) or costs for institutional controls.

5.3 Preliminary Remedial Alternatives Screening

Remedial alternatives are broadly screened against the three preliminary evaluation criteria (implementability, effectiveness, and cost), as described in detail in Section 4.1. As part of the evaluation of effectiveness, each alternative is also broadly evaluated with respect to the surrogate RALs. Following the screening evaluation, a determination is made in Section 5.4

to either retain or not retain each remedial alternative for further detailed analysis during development of the FS.

5.3.1 Alternative A – No Action

5.3.1.1 Implementability

Alternative A is implementable from both a technical and administrative basis because it requires no physical construction actions or off-site permits for implementation. Contaminated surface and subsurface sediments would remain in place throughout the various CMAs, and implementation of this alternative will likely require extensive long-term institutional controls regarding allowable use of the waterway to prevent spread of contaminated sediment. Additionally, the No Action alternative can be implemented without impacting the critical site restrictions (i.e., structural stability of existing bulkheads and over-water piers, minimum navigation elevations) at the site.

For these reasons, the No Action alternative is assigned a “high” ranking for both technical and administrative implementability.

5.3.1.2 Effectiveness

Short-term effectiveness: The No Action alternative is not effective in the short-term as no remedial actions are proposed to immediately reduce sediment contaminant concentrations. Although the technology is implementable, it will not result in achieving the surrogate RALs in the short-term. Although there are no short-term impacts to human health and the environment associated with this alternative, short-term effectiveness is still considered low as there is no immediate reduction in sediment contaminant concentrations.

Long-term effectiveness: Long-term effectiveness of this remedial alternative is considered low as no remedial actions are proposed that will help to meet surrogate RALs in the long-term. In general, the No Action alternative will not be protective of human health and the environment.

Alternative A is therefore assigned a “low” ranking for both short and long-term effectiveness.

5.3.1.3 Cost

There is no construction cost associated with implementation of the No Action remedial alternative for the purposes of this preliminary evaluation effort. Costs associated with long-term operation and maintenance and implementation of necessary institutional controls associated with Alternative A will be evaluated during development of the detailed FS.

For the purposes of this preliminary evaluation, cost is assigned a "low" ranking for Alternative A.

5.3.1.4 Alternative A Summary

The No Action alternative does not meet requirements of the preliminary evaluation criteria for short- and long-term effectiveness; however, it is retained for inclusion in the FS as it represents the baseline conditions for comparison to other proposed remedial alternatives and is required by EPA guidance to be carried forward into the FS.

5.3.2 Alternative B – Monitored Natural Recovery in All Areas Exceeding SQS Criteria

5.3.2.1 Implementability

Alternative B is implementable from a technical and administrative standpoint as no construction actions are necessary to implement the alternative, and implementation does not result in adverse impacts to existing and predicted future site use within the waterway.

Similar to the No Action alternative (Alternative A), contaminated surface and subsurface sediments would remain in place throughout the various CMAs, and implementation of this alternative will likely require extensive long-term institutional controls regarding allowable use of the waterway to prevent spread of contaminated sediment.

Alternative B is assigned a "high" ranking for both technical and administrative implementability.

5.3.2.2 Effectiveness

Short-term effectiveness: Alternative B is not effective in the short-term as no remedial actions are proposed to immediately reduce sediment contaminant concentrations, other than monitoring the recovery rate of surface sediment. Although the technology is implementable, it will not result in achieving the surrogate RALs in the short-term. Additionally, there are no short-term impacts to human health and the environment associated with this alternative; however, short-term effectiveness is still considered low to moderate as there is no immediate reduction in sediment contaminant concentrations throughout the site.

Long-term effectiveness: Long-term effectiveness of this remedial alternative is considered low as the remedy relies only on natural deposition of clean sediment to help meet the surrogate RALs in the long-term. Alternative B will have greater effectiveness in the long-term within areas of the EW OU where natural deposition of clean sediment occurs and erosive forces are not present. Alternative B is not expected to achieve the surrogate RALs for reduction in human and ecological risk in all parts of the EW OU in the long-term. Although sediment deposition rates may be higher in some parts of the waterway than others, not all areas are likely to adequately recover in acceptable timeframes. In addition, MNR by itself is not considered to be an effective remedial alternative for the EW OU due to the potential for resuspension of surface and subsurface contaminated sediment from erosive forces (such as propeller wash) in the Federal Navigation Channel, Underpier Area, and Berthing Area CMAs. Although the alternative does not adversely impact current or predicted future waterway use, it does not provide a remedy that is protective of human and ecological health throughout the EW.

Alternative B is assigned a "low" ranking for both short and long-term effectiveness.

5.3.2.3 Cost

Preliminary construction costs associated with implementation of Alternative B are approximately $4,400,000; costs are primarily associated with long-term monitoring requirements for the remedy. A summary cost table is presented in Appendix A. For the purposes of this preliminary evaluation, cost is assigned a "low" ranking for Alternative B.

5.3.2.4 Alternative B Summary

The Monitored Natural Recovery in All Areas Exceeding SQS Criteria alternative does not meet the preliminary evaluation criteria for short and long-term effectiveness. Although the alternative presents an implementable approach for management of contaminated sediment and does not generate short-term impacts, it does not include an effective approach that is protective of surrogate RALs.

The Monitored Natural Recovery in All Areas Exceeding SQS Criteria alternative is not retained for evaluation in the FS; however, the MNR technology will be retained for use in development of combination-technology remedial alternatives, within specific CMAs where it can be implemented in a manner that meets the evaluation criteria requirements.

5.3.3 Alternative C – Enhanced Natural Recovery in All Areas Exceeding SQS Criteria

5.3.3.1 Implementability

ENR is a technically implementable remedial technology in all areas of the site where placement of the ENR material would not impede existing uses of the waterway as summarized in Table 3. Additionally, placement of ENR material in the Underpier Area and Sill Reach CMAs of the site is considered to be technically implementable, though with more difficulty than placing ENR in open-water areas, and can be completed using construction equipment that is readily available in the region.

ENR is generally implementable from an administrative standpoint since EPA and regulatory agencies are familiar with the technology and construction methods that are proven based on experience at other local sites. Material resources are readily available for implementation of the ENR alternative. ENR may potentially decrease navigation and berthing elevations in the berth, slip, and navigation channel CMAs; however, for the purposes of evaluating this alternative in this Screening Memo, use of ENR is not considered to significantly limit implementability. ENR is assumed to consist of placing a nominal 9-inch-thick layer of clean sand. Because the ENR material is designed to mix with existing surface sediments and is not intended to remain undisturbed to act as an in situ containment technology, some limited propeller wash mixing of ENR material is likely to be acceptable.

Institutional controls will likely also be required within the areas of the site where ENR is placed and in areas where the existing surface sediments are in compliance with cleanup criteria, in order to prevent disturbance to these areas from erosive forces (such as propeller wash) until the clean ENR material has had sufficient time to mix with contaminated surface sediments.

The ENR alternative is assigned a "moderate" ranking for both technical and administrative implementability.

5.3.3.2 Effectiveness

Short-term effectiveness: The short-term effectiveness associated with the ENR alternative is high in that risk to human and ecological health is reduced immediately following placement of ENR material within the contaminated surface sediment areas of the site, and the remedy has a short construction window and low short-term impacts to the community (e.g., noise, air quality) and the environment. However, the alternative is not protective of underlying subsurface contamination in areas that have very high surface concentrations (greater than 3 times the surrogate RALs), or will be susceptible to erosive forces such as vessel wake and propeller wash in the short-term.

Long-term effectiveness: The ENR alternative is not considered to be effective in the long-term for all areas of the EW. ENR is an expedited natural recovery process and, for the Screening Memo, natural recovery processes are assumed to be effective in areas that experience net deposition but do not experience significant erosive forces, especially in areas where surface concentrations are not too high or in areas where underlying subsurface contamination is covered with clean surface sediment. Most of the EW is actively used for vessel traffic, including tug boats and container ships (Anchor QEA and Coast and Harbor 2011, in prep) and several of the CMAs experience significant erosive forces from propwash, including the Federal Navigation Channel and Berthing Areas CMAs. In these areas (and where surface concentrations are too high or underlying subsurface contamination is present), long-term effectiveness is low. Over the long-term, the clean ENR material mixes with underlying contaminated sediments, resulting in a mixed surface sediment concentration that may not be protective in all site areas. As a result, the long-term mixed surface sediment concentration may not achieve the surrogate RALs in the long-term within site areas where erosive forces are present and where existing surface concentrations are significantly elevated above the cleanup criteria, coupled with the presence of underlying subsurface contamination.

Alternative C is assigned rankings of "moderate to high" for short-term effectiveness and "low" for long-term effectiveness. An overall ranking of "low to moderate" is assigned to ENR for effectiveness.

5.3.3.3 *Cost*

The cost for implementation of Alternative C is $10,730,000. A summary cost table is presented in Appendix A. Primary cost drivers for this alternative include purchase and placement of the ENR material and monitoring of sediment conditions following completion of construction activities. Additional costs associated implementation of institutional controls associated with the ENR alternative are not included in this order-of-magnitude cost estimate. For the purposes of this preliminary evaluation, cost is assigned a "low to moderate" ranking for Alternative C.

5.3.3.4 *Alternative C Summary*

A remedial alternative relying on ENR for all areas above the SQS surrogate RALs does not meet the preliminary evaluation criteria requirements for effectiveness. Although ENR is technically implementable and is effective in the short-term for management of contaminated sediment, ENR has reduced long-term effectiveness in some areas of the site due to significant erosive forces in the EW disturbing and transporting the ENR material in areas with underlying subsurface contamination.

The Enhanced Natural Recovery in All Areas Exceeding SQS Criteria alternative is not retained for evaluation in the FS; however, the ENR technology will be retained for use in development of combination-technology remedial alternatives, within specific CMAs where it can be implemented in a manner that meets the evaluation criteria requirements.

5.3.4 Alternative D – Cap All Areas Exceeding SQS Criteria

5.3.4.1 Implementability

The Cap All Areas Exceeding the SQS Criteria alternative assumes an engineered cap will be placed using conventional placement equipment and techniques, and is considered technically implementable in all CMAs with the exception of the Underpier Areas and potentially portions of the Sill Reach CMA. Placement of an engineered cap in the Underpier Area CMAs is not technically implementable and considered infeasible without removal and replacement of the over-water pier structures and re-grading of underpier slopes to make the slope less steep (i.e., flatter than 3H:1V typical) to allow for construction of a stable cap. Therefore, capping under piers is not included as part of this alternative. Cap placement in the Sill Reach CMA is difficult due to the presence of the bridge structures that restrict equipment access.

Placement of an engineered cap in the various berth and federal navigation channel CMAs is not administratively implementable since reducing navigation and berthing elevations would not be compliant with maintaining existing authorized berthing and federal navigation channel elevations (i.e., federal navigation channel would need to be deauthorized under this alternative). Dredging within CMAs with authorized navigation and/or berthing elevations would be required prior to placement of the engineered cap in order to comply with these administrative site requirements.

Institutional controls (e.g., no anchoring restrictions) will likely also be required to minimize the potential for adverse impacts to cap stability and also to areas where the existing surface sediment are in compliance with cleanup criteria, but subsurface contamination remains. These institutional controls may have impacts on future maintenance activities (i.e., berth deepening) or waterway uses and would need to be coordinated in order to maintain ability to preserve functional use of the EW.

Given the considerations discussed above, technical implementability is assigned a ranking of "moderate" as caps can be placed in most areas of the EW (with the exception of Underpier Area and Sill Reach CMAs), while administrative implementability is assigned a ranking of "low" as the single-technology will not meet navigation and berthing depth requirements within the open-water areas. An overall ranking of "low" is assigned since capping by itself is not administratively implementable throughout most of the EW.

5.3.4.2 Effectiveness

Short-term effectiveness: Alternative D is effective in the short-term as it will immediately meet the surrogate RALs following completion of construction for compliance with sediment quality criteria. The capping technology will reduce the risk to human health and the environment through containment of existing surface and subsurface contaminated sediments within a majority of the CMAs. Additionally, impacts due to construction activities would be low to moderate as placement of the cap material limits in situ contaminated sediment resuspension. However, the overall short-term effectiveness is reduced due to the infeasibility of placement of an engineered cap within the Underpier Area and Sill Reach CMAs.

Long-term effectiveness: Alternative D is moderately effective in the long-term as the remedy does not provide long-term effectiveness within the site CMAs where it is infeasible to implement and, therefore, does not provide long-term reduction in contaminant concentrations that will meet the surrogate RALs in those areas. Additionally, the remedy will require extensive long-term maintenance and monitoring to ensure cap compliance with the cleanup criteria.

Alternative D is assigned a "moderate" ranking for both short- and long-term effectiveness as the technology cannot be implemented in certain CMAs and, therefore, does not provide risk reduction due to contaminated surface and subsurface sediments in these areas. Additionally, the Capping Alternative and would require long-term monitoring and maintenance to maintain its effectiveness.

5.3.4.3 Cost

The cost for implementation of Alternative D is $46,660,000. A summary cost table is presented in Appendix A, and primary cost drivers for this alternative includes procurement and placement of the cap material in the majority of the CMAs. Additional costs associated with implementation of institutional controls or long-term monitoring of the cap are not included in this order-of-magnitude cost estimate.

For the purposes of this preliminary evaluation, cost is assigned a ranking of "moderate" for implementation of Alternative D.

5.3.4.4 Alternative D Summary

The Cap All Areas Exceeding the SQS Criteria alternative does not meet the preliminary evaluation criteria for technical implementability in the Underpier Area and Sill Reach CMAs, and administrative implementability in the various berth and federal navigation channel CMAs. Although the alternative generally presents an effective approach for containment of contaminated sediment, it cannot be implemented as a single-technology alternative without causing significant waterway use restrictions in the various berth, slip, and navigation channel areas of the site or without removal of sediments prior to capping in various berth and navigation channel areas. Additionally, areas of the site where caps are not placed may be susceptible to erosion and exposure of underlying contaminated sediments, which also impact the long-term effectiveness of the remedial alternative.

The Cap All Areas Exceeding the SQS Criteria alternative is not retained for evaluation in the FS; however, the capping technology will be retained for use in development of combination-technology remedial alternatives, within specific CMAs where it can be implemented in a manner that meets the evaluation criteria requirements.

5.3.5 Alternative E – Dredge All Areas Exceeding the SQS Criteria with Upland Disposal

5.3.5.1 Implementability

The Dredge All Areas Exceeding the SQS Criteria with Upland Disposal alternative assumes that dredging would be implemented using mechanical dredging equipment within the nearshore and open-water areas and using specialty (diver-assisted hydraulic dredging) equipment in the Underpier Area CMAs. However, this alternative is only considered to be technically implementable for removal of surface and subsurface contamination within the EW if significant structural repairs and/or replacements of infrastructure are completed in conjunction with removal activities. In some CMAs (e.g., T-30/Nearshore, Shallow Main Body – Stations 6200 to 6850, Former Pier 24 Piling Field, Sill Reach, Berth Area, Slip 27 Channel/Pier 28, and Slip 36/T-36 Offshore CMAs), extensive structural and slope improvements or replacement of existing nearshore and overwater structures will likely be necessary (and constructible) to allow for complete contaminated sediment removal. In addition, other CMAs, such as the Sill Reach and Berth Areas CMAs, will require replacement of bridge structures in order to facilitate removal of the contaminated sediments in these areas. Evaluation of surface and subsurface sediment data from the EW OU indicates that deep dredge cuts would be required in many of the CMAs where structures are present, and a summary of structural limitations for each CMA is provided in Table 3. The alternative is considered technically implementable only if these structural considerations are addressed.

The Dredge All Areas Exceeding the SQS Criteria with Upland Disposal alternative assumes that all dredged material will be transferred to the uplands and taken to a permitted and licensed landfill facility for off-site disposal. Currently, there is no transload facility available within or near the EW OU; however, preliminary evaluation for administrative implementability of this alternative assumes that such a facility will be available, or could be constructed, when site remediation is scheduled to begin. The administrative implementability of this alternative is also challenged by the disruption to existing waterway use that would be generated in areas where existing structures would need to be taken out of service for improvement or replacement to allow for complete dredging.

The requirement for implementation of institutional controls will likely be minimal for this alternative as all contaminated sediment would be removed from the site and current and future waterway uses would be maintained.

Technical and administrative implementability are assigned a preliminary ranking of "low" for Alternative E as the technical implementability of removing all contaminated sediment adjacent to existing structures is not feasible without the need for significant structural improvements or replacement of existing structures (if constructable) throughout the EW OU, and the administrative implementability poses challenges with respect to waterway operational use when existing facilities are taken out of service.

5.3.5.2 Effectiveness

Short-term effectiveness: Release and resuspension of contaminants during dredging (dissolved or sorbed to suspended sediment particles) to the water column and potential sediment transport will likely result in water quality impacts during dredging, even if the removal area is enclosed by turbidity control devices or other dredging BMPs are used. Experience at similar sites indicates that an estimated 2% to 4% of the dredged contaminant mass is typically resuspended in the water column and transported (often as dissolved phase contaminants) out of the removal area (Palermo et al. 2008). During construction, this alternative is not anticipated to be able to achieve the surrogate RALs, due to residual contamination, until a residuals management cover has been placed following completion of dredging.

While sediment turbidity impacts in the removal area can be minimized in certain applications through the use of BMPs such as silt curtains, such BMPs have been demonstrated to be generally ineffective in areas with large tidal excursions and in generally reducing the downstream release of dissolved contaminants from any site. Dredging can result in elevated fish and shellfish tissue concentrations (USACE 2008; Bridges et al. 2010), and also has the potential to impact air and noise quality during construction. Therefore, the short-term effectiveness for this alternative is considered to be low due to the increased risk to human and ecological health during completion of dredging activities.

Long-term effectiveness: Long-term effectiveness of this remedial alternative is considered high in areas where dredging is technically implementable to remove all contaminated sediment. Long-term effectiveness is lower in areas where dredging may not be able to remove all of the contaminated sediment (e.g., berth areas that are adjacent to existing structures). This remedial alternative is considered to achieve the surrogate RALs in the long-term (after placement of the residuals management cover) and is protective of human health and the environment, due to a permanent reduction of surface and subsurface contaminated sediment volume.

The Dredge All Areas Exceeding the SQS Criteria with Upland Disposal alternative is given an overall ranking of "moderate."

5.3.5.3 Cost

The conceptual cost for implementation of Alternative E is $275,780,000. The conceptual cost accounts for complete removal of all contaminated sediment, and anticipated structural improvements and/or replacements that are necessary to complete the dredging activities. A summary cost table is presented in Appendix A, and primary cost drivers for this alternative include completion of required structural improvements/replacements, removal and disposal of the contaminated sediment at an off-site upland landfill facility, management of water quality during completion of the dredging activities, procurement and placement of residuals management cover material, and the need for specialty dredging equipment and techniques (i.e., diver-assisted hydraulic dredging) in all of the Underpier Area CMAs. Conceptual costs for structural and slope improvements or replacement of nearshore and over-water structures to support dredging activities have also been included for this screening evaluation. Additional costs associated with implementation of institutional controls are not included in this order-of-magnitude cost estimate.

For the purposes of this preliminary evaluation, cost is assigned a ranking of "high" for implementation of Alternative E.

5.3.5.4 Alternative E Summary

The Dredge All Areas Exceeding the SQS Criteria with Upland Disposal alternative does not meet requirements of the preliminary evaluation criteria for technical and administrative implementability, due to the potential need for significant structural improvements to support the dredging activities and the disruption of current waterway use that will be generated when existing structures are temporarily taken out of service. Although the alternative presents an effective and permanent approach for removal and management of contaminated sediment and debris, the implementability challenges and subsequent cost considerations make it an infeasible alternative.

The Dredge All Areas Exceeding the SQS Criteria with Upland Disposal alternative is not retained for evaluation in the FS; however, the dredging remedial technology will be retained for use in development of combination-technology remedial alternatives, within specific CMAs where it can be implemented in a manner that complies with structural limitations and meets the evaluation criteria requirements.

5.3.6 *Alternative F – Combination Technologies by Construction Management Area*

5.3.6.1 *Implementability*

Alternative F is implementable from a technical and administrative standpoint because the alternative utilizes different remedial technologies that can be implemented using available equipment and materials within individual CMAs that will meet the cleanup and evaluation criteria for the site. The remedial technology proposed for each CMA is based on proven technologies that have demonstrated success at other cleanup sites, and is presented on Figure 7 and summarized as follows:

- ENR is applied to the Junction Reach, Sill Reach, Shallow Main Body – Stations 6200 to 6850, and Shallow Main Body – Stations 5700 to 6200 CMAs where detected surface sediments are greater than the SQS surrogate RALs. Specific analysis of the ENR technology will be completed during development of the detailed FS; however, for screening purposes, this alternative assumes that ENR will bring surface sediment contamination concentrations into compliance with the surrogate RALs within an acceptable natural recovery timeframe for remediation of the EW OU. Additionally, MNR will be considered for implementation in the Shallow Main Body – Stations 5700 to 6200 CMA, following completion of natural recovery evaluations in the detailed FS.
- Capping will be conducted in the Former Pier 24 Piling Field as placement of a cap in these areas will allow for containment of surface and subsurface sediment contamination and not result in restrictions to current or projected future waterway operational use. Institutional controls will likely be applied to this area to prevent

future disturbance to the sediment caps and to allow for access to monitor cap performance and complete maintenance activities as necessary.

- Partial Dredging followed by Capping will be completed in the Mound Area/Slip 27 Shoreline, T-30/USCG Nearshore, Slip 27 Channel, and Communication Cable Crossing CMAs to allow for removal of some contaminated sediment prior to placement of the engineered cap. Dredging and Capping activities will be completed in the Mound Area/Slip 27 Shoreline and T-30/USCG Nearshore areas so that the cap does not interfere with federal navigation channel depth requirements, and within the Communication Cable Crossing area to prevent disturbance to the cable and allow for placement of an engineered cap that remains below the federal navigation channel elevation of -51 feet MLLW. Additionally, the existing shoreline habitat restoration area along the southern shoreline of Slip 27 will not be disturbed during implementation of this remedial alternative. Institutional controls will likely also be applied to these areas to prevent future disturbance to the sediment caps and to allow for access to monitor cap performance and complete maintenance activities as necessary.
- A combination of In situ Treatment (amendments) and ENR remedial technologies will be applied to Underpier Area CMAs that are greater than the SQS surrogate RALs as part of implementation of Alternative F. The alternative assumes that In situ Treatment and ENR will be applied to all polygons that exceed SQS in surface sediments. Implementation of these technologies in the Underpier Area CMA is considered to be technically implementable and the alternative assumes that mixing of materials due to propeller wash and other erosive forces will not result in significant recontamination of the EW OU. Specific evaluation of these remedial technologies for the Underpier Area CMA will be completed in the FS.
- Dredging and Backfill/Capping will be conducted in EW Berth Area CMAs, as described in Section 5.1, where surface sediments are greater than the SQS surrogate RALs. The combination of dredging and backfill/capping will allow for removal of contaminated sediment and placement of backfill or an engineered cap so that stability of nearshore and overwater structures and slopes is not jeopardized following implementation of the remedial technologies. Additionally, the combination of dredging and backfill/capping will also allow for preservation of required berthing elevations in these CMAs. Institutional controls will likely also be applied to the

capped areas to prevent future disturbance to the engineered caps and to allow for access to monitor cap performance and complete maintenance activities as necessary.

- Dredging with Residuals Management Cover will be completed in the Federal Navigation Channel and Slip 36/T-46 Offshore CMAs in areas greater than the SQS surrogate RALs. Implementation of this technology in these areas is feasible as removal of contaminated sediment will not jeopardize the stability of existing structures or slopes. Placement of the residuals management cover material within these areas is also implementable and can be completed using conventional construction equipment and placement methods.

Implementation of the proposed combination-technology remedial alternative assumes that a transload facility and upland disposal facility (i.e., landfill) will be available at the time of construction, and that other materials (i.e., capping, ENR, and residuals management cover) will be available from local sources.

Technical and administrative implementability are assigned "high" rankings based on the considerations described above for implementation of Alternative F.

5.3.6.2 *Effectiveness*

Short-term effectiveness: Alternative F is effective in the short-term as implementation of the various remedial technologies within the site CMAs will achieve the surrogate RALs throughout a significant portion of the site within a short timeframe. Implementation of the capping and ENR/in situ treatment technologies in areas of the site where erosive forces are present or access is difficult will help achieve the surrogate RALs in the near term. However, there will likely be short-term impacts associated with the large amount of dredging activities, resulting in generation of short-term risk to human health and the environment. Removal of sediment to the SQS surrogate RALs requires a significant amount of dredging within the proposed areas and, therefore, generates increased short-term risk for suspension and distribution of contaminated sediments that result in exposure to human (through seafood consumption pathways) and ecological receptors.

Long-term effectiveness: Long-term effectiveness of Alternative F is considered high as a significant amount of contaminated surface and subsurface contamination will have been removed from within the erosional areas of the site, and there will be a minimal need for maintenance of capped or ENR areas, as the total area of implementation for these technologies is relatively small. Implementation of the combination of technologies associated with Alternative F will result in completion of a remedy that will not require extensive long-term monitoring and maintenance to remain in compliance with the surrogate RALs.

For the purposes of this preliminary evaluation, a ranking of "moderate to high" is assigned to short-term effectiveness and a ranking of "high" is assigned to long-term effectiveness for Alternative F due to the immediate attainment of short- and long-term cleanup requirements for the EW OU to the SQS surrogate RALs.

5.3.6.3 Cost

The cost for implementation of Alternative F is $126,040,000. A summary table of costs for this alternative is presented in Appendix A, and the primary cost drivers for implementation of Alternative F are removal and disposal of contaminated sediment to the SQS surrogate RALs, and procurement and placement of residuals management cover material and capping materials. For the purposes of this preliminary evaluation, cost is assigned a ranking of "moderate to high" for implementation of Alternative F.

5.3.6.4 Alternative F Summary

The Combination Technologies by Construction Management Area alternative represents the type of remedial alternative that selects appropriate remedial technologies to be implemented in specific CMAs. The use of the combination technology approach allows for the alternative to meet the preliminary evaluation criteria and is representative of conservative remedial alternatives that should be evaluated in detail as part of the FS.

The Port and USACE do not have current plans to conduct navigational dredging within the EW OU. The previous dredging events described in the Screening Memo have provided sufficient depth to meet current Port and tenant navigation and berthing needs in the foreseeable future. Limited future maintenance dredging may be required, though the timeframe and areas requiring dredging are unknown. However, due to the relatively low predicted sedimentation rates within the EW, regular maintenance dredging is expected to be needed infrequently.

The Combination Technologies by Construction Management Area alternative is retained for evaluation in the FS, and, therefore, various combination alternatives will be assembled and evaluated in the FS to allow for comparison and selection of a recommended remedial alternative for the EW OU.

5.4 Summary of Remedial Alternatives

A summary of the preliminary remedial alternative evaluation, including designation of rankings and assumptions for each of the single-technology and combination-technology remedial alternatives described above is provided in Table 19. As discussed in Section 5.3, Alternatives A (No Action) and Alternative F (Combination Technologies by Construction Management Area) are retained for further evaluation in the FS. Alternatives B, C, D, and E are not retained for further evaluation.

Table 19

Preliminary Remedial Alternative Evaluation Summary

Preliminary Screening Criteria[1]	Preliminary Remedial Alternatives					
	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
	No Action	Monitored Natural Recovery (MNR) in all Areas Exceeding SQS Criteria	Enhanced Natural Recovery (ENR) in All Areas Exceeding SQS Criteria	Cap All Areas Exceeding SQS Criteria	Dredge All Areas Exceeding the SQS Criteria with Upland Disposal	Combination Technologies by Construction Management Area
Implementability						
Technical	High	High	Moderate	Moderate	Low	High
Administrative	High	High	Moderate	Low	Low	High
Effectiveness						
Short-Term	Low	Low	Moderate to High	Moderate	Low to Moderate	Moderate to High
Long-Term	Low	Low	Low	Moderate	High	High
Cost[2, 3]						
Preliminary Conceptual Cost	NA	$4.4M	$10.8M	$46.7M	$275.8M	$126.1M
Cost Ranking	Low	Low	Low to Moderate	Moderate	High	Moderate to High
Screening Decision	Retained	Not Retained	Not Retained	Not Retained	Not Retained	Retained
Evaluation Summary						
	Alternative A does not meet requirements of preliminary evaluation criteria, but it retained as a single-technology remedial alternative for baseline comparison to other alternatives that will be evaluated in the FS.	Alternative B does not meet requirements of the preliminary evaluation criteria for short- and long-term effectiveness as it relies on the natural recovery process to be successful in areas of the East Waterway OU that are susceptible to erosion and exposure of underlying contaminated sediments in berthing areas and the navigation channel. The MNR alternative is not retained as a single-technology alternative for further evaluation in the FS.	Alternative C does not meet requirements of the preliminary evaluation criteria for long-term effectiveness as implementation of the ENR technology is susceptible to erosion and exposure of underlying contaminated sediments in berthing areas and the navigation channel. The ENR alternative is not retained as a single-technology alternative for further evaluation in the FS.	Alternative D does not meet requirements of the preliminary evaluation criteria for technical implementability in the underpier CMAs because placement of an engineered cap is considered infeasible in these areas, due to structural limitations of the existing piers. The alternative does not meet requirements for administrative implementability as berth and navigation channel operational elevations must be maintained from a waterway use perspective. The Capping alternative is not retained as a single-technology alternative for further evaluation in the FS.	Alternative E does not meet requirements of the preliminary evaluation criteria for technical and administrative implementability due to the need for significant structural improvements to support the dredging activities, and disruption of current waterway use that will be generated when existing structures are temporarily taken out of service. The Dredge with Upland Disposal alternative is not retained as a single-technology alternative for further evaluation in the FS.	Alternative F meets the requirements of the preliminary evaluation criteria for technical and administrative implementability and short- and long-term effectiveness, as it proposes remedial technologies that are feasible for implementation within each CMA and that will be effective in the short- and long-term without generating unreasonable risk. Alternative F represents an example of the type of remedial alternative that will be aggregated and evaluated in detail as part of development of the FS.

Notes:

1) Definitions of preliminary screening criteria are presented in Section 4.1.
2) Cost estimates for the remedial alternatives are considered conceptual and should be used for comparison purposes only. Detailed and complete remedial alternative cost estimates will be prepared during development of the FS.
3) Cost estimates do not include costs associated with long-term operations and maintenance (O&M), regulatory agency coordination, engineering design, construction contingencies, contractor procurement, and project management.

6 CONCLUSIONS AND RECOMMENDATIONS

The goal of this Screening Memo is to identify types of remedial and disposal technologies and remedial alternatives to be carried forward for detailed evaluation in the EW FS. This Screening Memo satisfies required deliverables set forth in the SRI/FS Workplan (Anchor and Windward 2007), prepared in response to the ASAOC and SOW (EPA 2006), including preparation of both the Disposal Site Alternatives Identification and Screening Memorandum and the Remedial Alternatives Screening Memorandum. Review of each remedial and disposal technology and remedial alternative was conducted using the effectiveness, implementability, and cost criteria consistent with EPA guidance (EPA 1988). Conclusions presented in this Screening Memo identify the combination technology alternative approach as an acceptable method for assembly of remedial alternatives in the FS. The specific technology combinations described in this document will be expanded upon for detailed evaluation in the FS.

Each of the retained remedial and disposal technologies and remedial alternatives will be evaluated in detail in the FS using specific CERCLA criteria. The FS may also evaluate other remedial alternatives or variations of the Screening Memo's retained remedial alternatives, considering information provided in the SRI Report and development of the RAOs, PRGs and RALs. The following conclusions and recommendations will be carried forward into the FS:

1. Structural and use limitations associated with CMAs within the EW limit implementation of specific remedial technologies in specific areas. This Screening Memo provides a summary of the major structural and use limitations, but the FS will provide a more detailed technology and alternative screening with respect to these limitations.
2. Remedial technologies carried forward are summarized in Table 12, and include no action, institutional controls, MNR, ENR, in situ containment, removal, and specific in situ and ex situ treatment technologies. Additionally, some technologies eliminated in this evaluation may not be discussed in the FS, but could be re-considered during remedial design if site conditions change or additional information becomes available, as directed by EPA.

3. The disposal site technology that was retained was upland landfill disposal. Other disposal technologies may be revisited as part of Remedial Design, but are not included for further evaluation in the FS.
4. Single technology remedial alternatives do not meet the preliminary evaluation criteria and are not retained for detailed evaluation in the FS; however, single technologies are applicable for implementation in specific CMAs.
5. The No Action single-technology alternative will be carried forward, as is required by EPA guidance and represents the baseline condition for comparison of alternatives during development of the FS.
6. The Combination Technologies by Construction Management Area alternative was developed, screened, and found to meet the preliminary evaluation criteria. Alternative F represents an example of the type of remedial alternatives that will be assembled and carried forward for detailed evaluation as part of the FS process.
7. Various combination alternatives will be assembled and evaluated in the FS so that an acceptable comparison of combination alternatives can be conducted to select a recommended remedial alternative for the site.

Next steps in the SRI/FS process include development of the RAO Memorandum, which will be submitted to EPA following finalization of the risk assessments. The Draft SRI Report will be submitted in early 2012. The Draft FS Report will be based on the SRI Report and Baseline HHRA and ERA. Additional site-specific data and information presented in these reports will be used to develop the Draft FS Report. Although a remedial technology may have been screened out during this Screening Memo, additional site-specific information may not preclude re-consideration of a screened out technology if that technology could be implemented and effective. In addition, newer technologies or technologies overlooked in this evaluation may be appropriate to evaluate during the FS and or/remedial design processes.

7 REFERENCES

AECOM, 2010. Lower Duwamish Waterway, Draft Final Feasibility Study. For submittal to U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology. AECOM, Seattle, WA.

Alcoa Inc., 2010. Activated Carbon Pilot Study 2008 Monitoring Results Summary Report. Grasse River Study Area, Massena, New York. Prepared by Anchor QEA Engineering, PLLC, ARCADIS, and the University of Maryland Baltimore County. February 2010.

Anchor, 2000. Preliminary Draft Disposal Site Alternatives Evaluation, EW Deepening Project. Prepared for Port of Seattle. August 9.

Anchor and Windward, 2005. East Waterway Operable Unit Phase 1 Removal Action Completion Report. Submitted to the U.S. Environmental Protection Agency. September 30.

Anchor and Windward, 2007. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Final Workplan. Prepared for Port of Seattle. July.

Anchor and Windward, 2008. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Final Existing Information Summary Report (EISR). Prepared for Port of Seattle. March.

Anchor and Windward, 2009. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Final Initial Source Evaluation and Data Gaps Memorandum (SEDGM). Prepared for Port of Seattle. December.

Anchor, Windward, and Battelle, 2008. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Final Conceptual Site Model and Data Gaps Analysis Report. Prepared for Port of Seattle. December.

Anchor QEA and Coast and Harbor, 2011. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Draft Sediment Transport Evaluation Report (STER). Prepared for Port of Seattle. July 29.

Averett D., M.R. Palermo, and R. Wade, 1988. Verification of Procedures for Designing Dredged Material Containment Areas for Solids Retention. Miscellaneous Paper D-88-

2. U.S. Army Corps of Engineers, Dredging Operations Technical Support Program. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Boatman, C and D. Hotchkiss, 1994. Nearshore Confined Disposal in a Tidally Influenced Environment-Design and Operation Experience in Puget Sound. Proceedings of the Second International Conference on Dredging and Dredged Material Placement. November.

Boatman, C and D. Hotchkiss, 1997. Tidally Influenced Containment Berm Functioning as a Leachate Treatment Cell – Puget Sound Experience in Confined Disposal of Contaminated Sediments. Proceedings of the International Conference on Contaminated Sediments, Rotterdam, the Netherlands. September.

Brannon et al., 1990. Comprehensive Analysis of Migration Pathways (CAMP): Contaminant Migration Pathways at Confined Dredged Material Disposal Facilities.

Bridges, T., K. Gustavson, P. Schroeder, S. Ells, D. Hayes, S. Nadeau, M. Palermo, and C. Patmont, 2010. Dredging Processes and Remedy Effectiveness: Relationship to the Four Rs of Environmental Dredging. Integrated Environmental Assessment and Management. 2010, 6, 619–630.

Cho, Y., U. Ghosh, A.J. Kennedy, A. Grossman, G. Ray, J.E. Tomaszewski, D. Smithenry, T.S. Bridges, and R.G. Luthy, 2009. Field application of activated carbon amendment for in situ stabilization of polychlorinated biphenyls in marine sediment Environ. Sci. Technol. 2009, 43, 3815– 3823.

Cornelissen, G., M.E. Krus, G.D. Breedveld, E Eek, A.M.P. Oen, H.P.H. Arp, C. Raymond, G. Samuelsson, J. E. Hedman, O. Stokland, and J.S. Gunnarsson, 2011. Remediation of Contaminated Marine Sediment Using Thin-Layer Capping with Activated Carbon—A Field Experiment in Trondheim Harbor, Norway. Environ. Sci. Technol. 2011, 45, 6110–6116.

Desrosiers, R., and C. Patmont, 2009. Environmental Dredging Residuals – Case Study Summaries and Analyses. In: G.S. Durell and E.A. Foote (Conference Chairs), Remediation of Contaminated Sediments – 2009. Battelle Memorial Institute, Columbus, OH.

DMMP, 2010. Dredged Material Management Program New Interim Guidelines for Dioxins. http://www.nws.usace.army.mil/PublicMenu/documents/DMMO/New_Interim_Guidelines_for_Dioxins.pdf. December.

Ecology, 1990. Standards for Confined Disposal of Contaminated Sediments Development Document. Washington State Department of Ecology. Olympia, WA.

Ecology, 1991. Multi-User Sites for the Confined Disposal of Contaminated Sediments from Puget Sound. Report submitted to Puget Sound Water Quality Authority, Olympia, WA, pursuant to Element S-6 (Multi-user Disposal Sites Study) of the Puget Sound Water Quality Management Plan. Washington State Department of Ecology. Olympia, WA. October.

Ecology, 2001. Multi-User Disposal Site Investigation. Report prepared by Science Applications International Corporation. Washington State Department of Ecology. Olympia, WA. June.

EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. EPA/540/G-89/004. U.S. Environmental Protection Agency.

EPA, 1991. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual. Part B, Development of Preliminary Remediation Goals. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response, Washington, DC. EPA 540-R-92-003.

EPA, 1994. ARCS Remediation Guidance Document. EPA 905-B94-003. Chicago, IL: Great Lakes National Program Office. U.S. Environmental Protection Agency.

EPA, 1996. Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5. Contract Document 68-CO-0068-43. U.S. Environmental Protection Agency, Region 5. Chicago, IL.

EPA, 1997. Rules of Thumb for Superfund Remedy Selection. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response, Washington, DC. EPA 540-R-97-013.

EPA, 1999. A Guide for Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents, EPA 540R-98-031. Washington, D.C.: U.S. Environmental Protection Agency. July.

EPA, 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. OSWER 9355.0-85. U.S. Environmental Protection Agency. EPA-540-R-05-012. December.

EPA, 2006. Administrative Settlement Agreement and Order on Consent for the Supplemental Remedial Investigation and Feasibility Study of the East Waterway Operable Unit of the Harbor Island Superfund Site. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA, 2011. EPA and Ecology comments on Lower Duwamish Waterway Revised Draft Feasibility Study (submitted October 15, 2010). U.S. Environmental Protection Agency Region 10, Seattle, WA. February 25.

EPA and USACE, 2000. Hudson River PCBs Reassessment RI/FS Feasibility Study. U.S. Environmental Protection Agency, Region 2, and U.S. Army Corps of Engineers, Kansas City District. Website: http://www.epa.gov/hudson/study.htm.

Ghosh, U., 2010. Contaminated Sediments: New Tools and Approaches for in situ Remediation - Session II. CLU-IN Internet Seminar Sponsored by: National Institute of Environmental Health Sciences, Superfund Research Program. December 8, 2010. Presentation available at http://www.clu-in.org/conf/tio/sediments2_120810/.

Ghosh, U., R.G. Luthy, G. Cornelissen, D. Werner, and C.A. Menzie, 2011. In-situ Sorbent Amendments: A New Direction in Contaminated Sediment Management. Environ. Sci. Technol. 2011, 45, 1163–1168.

Hart Crowser, 1996. Design Analysis Report, West Harbor Operable Unit, Wyckoff/Eagle Harbor Superfund Site, Kitsap County, Washington. Prepared for PACCAR Inc and Washington State Department of Transportation and Natural Resources. May 29.

Janssen, E.M-L., J.K. Thompson, S.N. Luoma, and R.G. Luthy, 2011. PCB-induced changes of a benthic community and expected ecosystem recovery following in situ sorbent amendment. Presentation to SedNet. Venice, Italy. April 6-9, 2011. Presentation available at http://www.sednet.org/download/Presentation8-Janssen.pdf.

Janssen, E.M-L., M.N. Elecroteau, S.N. Luoma, and R.G. Luthy, 2009. Measurement and Modeling of Polychlorinated Biphenyl Bioaccumulation from Sediment for the

Marine Polychaete Neanthes arenaceodentata and Response to Sorbent Amendment. Environ. Sci. Technol. 2009. Volume 44, Number 8, 2857–2863.

King County, 1999. King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay. Vol 1: Overview and Interpretation, plus Appendices. King County Department of Natural Resources, Seattle, WA.

King County, 2005. WRIA 9 Strategic Assessment Report - Scientific Foundation For Salmonid Habitat Conservation. Prepared for Water Resources Inventory Area (WRIA) 9 Steering Committee. King County Department of Natural Resources and Parks, Seattle, WA.

Luthy, R.G., Y-M Cho, U. Chosh, T.S. Bridges, and A.J. Kennedy, 2009. Field Testing of Activated Carbon Mixing and In situ Stabilization of PCBs in Sediment at Hunters Point Shipyard Parcel F, San Francisco Bay, California. Environmental Security Technology Certification Program Project No. ER-0510. August 5, 2009.

Menzie, C.A., 2011a. Contaminated Sediments: New Tools and Approaches for in situ Remediation - Session III. CLU-IN Internet Seminar Sponsored by: National Institute of Environmental Health Sciences, Superfund Research Program. January 19, 2011. Presentation available at http://www.clu-in.org/conf/tio/sediments3_011911/

Menzie, C.A., 2011b. The Use of Pilot Studies for Assessing In situ Sediment Treatment with Activated Carbon. Presentation to the Sediment Management Work Group. Philadelphia, PA. October 5, 2011.

Muckleshoot Indian Tribe and Port of Seattle, 2006. Letter of Agreement between Muckleshoot Indian Tribe and Port of Seattle Regarding Slip 27 and Terminal 115. July 13.

NavFac, 1986. Design Manual DM-7.02, SN 0525-LP-300-7071. Foundations and Earth Structures. Naval Facilities Engineering Command, Alexandria, VA.

NOAA, 2009. Seattle Harbor, Elliott Bay and Duwamish Waterway. NOAA raster navigation chart 18450, edition 18 [online]. Office of Coast Survey, National Oceanic and Atmospheric Administration, Silver Spring, MD. Updated 7/17/09. [Cited 11/19/09.] Available from: http://www.charts.noaa.gov/OnLineViewer/18450.shtml.

NRC, 2007. Sediment Dredging at Superfund Megasites - Assessing the Effectiveness. National Research Council, Washington, DC: National Academy Press.

Oates, 2007. Personal communication (conversation with Anchor Environmental, L.L.C. staff regarding utility locate of underwater cables as part of T-18 bulkhead construction in 2003). KPFF Consulting Engineers, Olympia, WA.

Oen, A.M.P., and G. Cornelissen, 2010. In situ sediment remediation through activated carbon amendment: Trondheim Harbour and other field trials. Presentation at Sediment Workshop 2010 in Nepal. Kathmandu, Nepal. November 14-21, 2010.

Oen, A.M.P., E.M.L. Janssen, G. Cornelissen, G.D. Breedveld, E. Eek, and R.G. Luthy, 2011. In situ measurement of PCB pore water concentration profiles in activated carbon-amended sediment using passive samplers. Environ. Sci. Technol. 2011, 44, 4053–4059.

Palermo, M., 2002. "A State of the Art Overview of Contaminated Sediment Remediation in the United States." In: (A. Porta and R.E. Hinchee, eds) Proceedings of the First International Conference on Remediation of Contaminated Sediments, 10-12 October 2001, Venice, Italy. Battelle Press. Website: http://www.battelle.org/bclscrpt/bookstore/booktemplate.cfm?ISBN=1%2D57477%2D125%2D6.

Palermo, M., 2009. In Situ Volume Creep for Environmental Dredging Remedies. Fifth International Conference on Remediation of Contaminated Sediments, D3. Jacksonville, Florida. February 4.

Palermo, M.R., J.E. Clausner, M.P. Rollings, G.L. Williams, T.E. Myers, T.J. Fredette, and R.E. Randall, 1998a. Guidance for Subaqueous Dredged Material Capping. Technical Report DOER-1. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi. Website: http://www.wes.army.mil/el/dots/doer/pdf/doer-1.pdf.

Palermo, M.R., J. Miller, S. Maynord, and D. Reible, 1998b. Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In-Situ Subaqueous Capping of Contaminated Sediments. EPA 905/B-96/004. Prepared for the Great Lakes National Program Office, U.S. Environmental Protection Agency, Chicago, Illinois. Website: http://www.epa.gov/glnpo/sediment/iscmain.

Palermo, M.R., P.R. Schroeder, T.J. Estes, and N.R. Francingues, 2008. Technical Guidelines for Environmental Dredging of Contaminated Sediments. ERDC/EL TR-08-29. September.

Patmont, C., and M. Palermo, 2007. Case Studies of Environmental Dredging Residuals and Management Implications. Paper D-066, in: Remediation of Contaminated Sediments—2007, Proceedings of the Fourth International Conference on Remediation of Contaminated Sediments. Savannah, Georgia. January.

Port of Tacoma, 1992. Sitcum Waterway Remediation Project: Phase 1 Pre-Remedial Design Evaluation and Phase 2 Preliminary Evaluation of Remedial Options Report. September 30.

RETEC, 2005. Lower Duwamish Waterway Remedial Investigation/Feasibility Study, Final Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site. Prepared for U.S. Environmental Protection Agency, Region 10, and Washington State Department of Ecology. December 12.

Sumeri, A., 1984. "Capped In-Water Disposal of Contaminated Dredged Material," in "Dredging and Dredged Material Disposal" (Vol 2), R.L. Montgomery and J.W. Leach, eds., Proceedings of Conference Dredging '84, American Society of Civil Engineers, Clearwater Beach, FL.

Sumeri, A., 1989. "Confined Aquatic Disposal and Capping of Contaminated Sediments in Puget Sound," Proceedings of WODCON XII; Dredging: Technology, Environmental, Mining, World Dredging Congress, Orlando, FL.

Terralogic, Landau, 2004. Lower Duwamish Inventory Report. Prepared for WRIA 9 Steering Committee and Seattle Public Utilities. TerraLogic GIS, Inc., Stanwood, WA, and Landau Associates, Edmonds, WA.

Tetra Tech Inc., 2010. Lockheed West Seattle Superfund Site. Final Screening of Remedial Technologies and Assembly of Preliminary Alternatives. Prepared for Lockheed Martin. November.

Thompson, T., G. Hartman, C. Houck, J. Lally, and R. Paulson, 2003. Methods and Considerations for Cap Design, Contracting, Construction, and Monitoring over Soft, Unconsolidated Sediments. Proceedings of the In-Situ Contaminated Sediment Capping Workshop. May.

USACE, 1987. Engineering and Design – Confined Disposal of Dredged Material. Engineer Manual No. 1110-2-5027. U.S. Army Corps of Engineers, Washington, D.C.

USACE, 1994. Sediment Chemistry Profiles of Capped Deposits Taken 3 to 11 Years After Capping. Dredging Research Technical Notes. DRP-549. May.

USACE, 1997. Multi-User Disposal Sites (MUDS) for Contaminated Sediments from Puget Sound – Subaqueous Capping and Confined Disposal Alternatives. Prepared for U.S. Army Corps of Engineers, Seattle District, by M.R. Palermo, J.E. Clausner, M. Channel, and D.E. Averett. Dredging Operations and Environmental Research Program, Waterways Experiment Station, Vicksburg, MS.

USACE, 2000. Innovative Dredged Sediment Decontamination and Treatment Technologies. U.S. Army Corps of Engineers, ERDC TN-DOER-T2. December.

USACE, 2003. Feasibility Phase Final Report Puget Sound Confined Disposal Site Study, Washington. U.S. Army Corps of Engineers.

USACE, 2005. Howard Hanson Dam Reservoir Operations and Sediment Management Plan for Water Year 2006, Appendix C: Water Quality Sampling and Analysis Plan. Prepared by U.S. Army Corps of Engineers, Seattle District, Water Management Section, Seattle, Washington. December.

USACE, 2007. Howard Hanson Dam. http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=HHD&pagename=mainpage. Accessed: November 30, 2007.

USACE, 2008. The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk. Technical Report ERDC/EL TR-08-4. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://el.erdc.usace.army.mil/elpubs/pdf/trel08-4.pdf.

USACE, 2010. Letter from Stuart R. Cook (Chief, Operations Division) to Allison Hiltner (USEPA) regarding Duwamish River – Dredging Buffer Zone Needs in the Federal Navigation Channel. August 3.

USACE, Ecology, and DNR, 1999. Puget Sound Confined Disposal Site Study Programmatic NEPA/SEPA Environmental Impact Statement. Prepared in cooperation with Striplin

Environmental Associates, Anchor Environmental, Ogden Beeman Associates, ECO Resource Group, EnviroIssues, and Marshal and Associates. U.S. Army Corps of Engineers, Washington State Department of Ecology, and Washington State Department of Natural Resources. Two volumes. October.

Windward, 2003. Lower Duwamish Waterway Phase 1 Remedial Investigation Report. Final. Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, WA, and Washington Department of Ecology, Bellevue, WA. Windward Environmental LLC, Seattle, WA.

Windward, 2008. East Waterway Human Access Survey Report. Draft. Windward Environmental LLC, Seattle, WA.

Windward, 2009a. Final Data Report: Benthic Invertebrate Tissue and Co-located Sediment Samples. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2009b. Final Surface Water Data Report. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2010a. East Waterway Operational Unit, Supplemental Remedial Investigation/Feasibility Study, Final Data Report: Surface Sediment Sampling For Chemical Analyses and Toxicity Testing. Windward Environmental LLC, Seattle, WA. September.

Windward, 2010b. Data Report: Clam Survey, Geoduck Survey, Fish and Shellfish Tissue Collection PCB Congener and Dioxin/Furan Results. Final. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2010c. Data Report: Clam Surveys and Sampling of Clam Tissue and Sediment. Final. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2010d. Data Report: Fish and Shellfish Tissue Collection. Final. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2010e. Data Report: Juvenile Chinook Salmon Tissue Collection. Final. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2010f. Data Report: Surface Sediment Sampling for Chemical Analyses and Toxicity Testing. Final. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study. Windward Environmental LLC, Seattle, WA.

Windward, 2010g. Final Remedial Investigation Report. Lower Duwamish Waterway Remedial Investigation. Submitted to USEPA and the Washington State Department of Ecology. July 9.

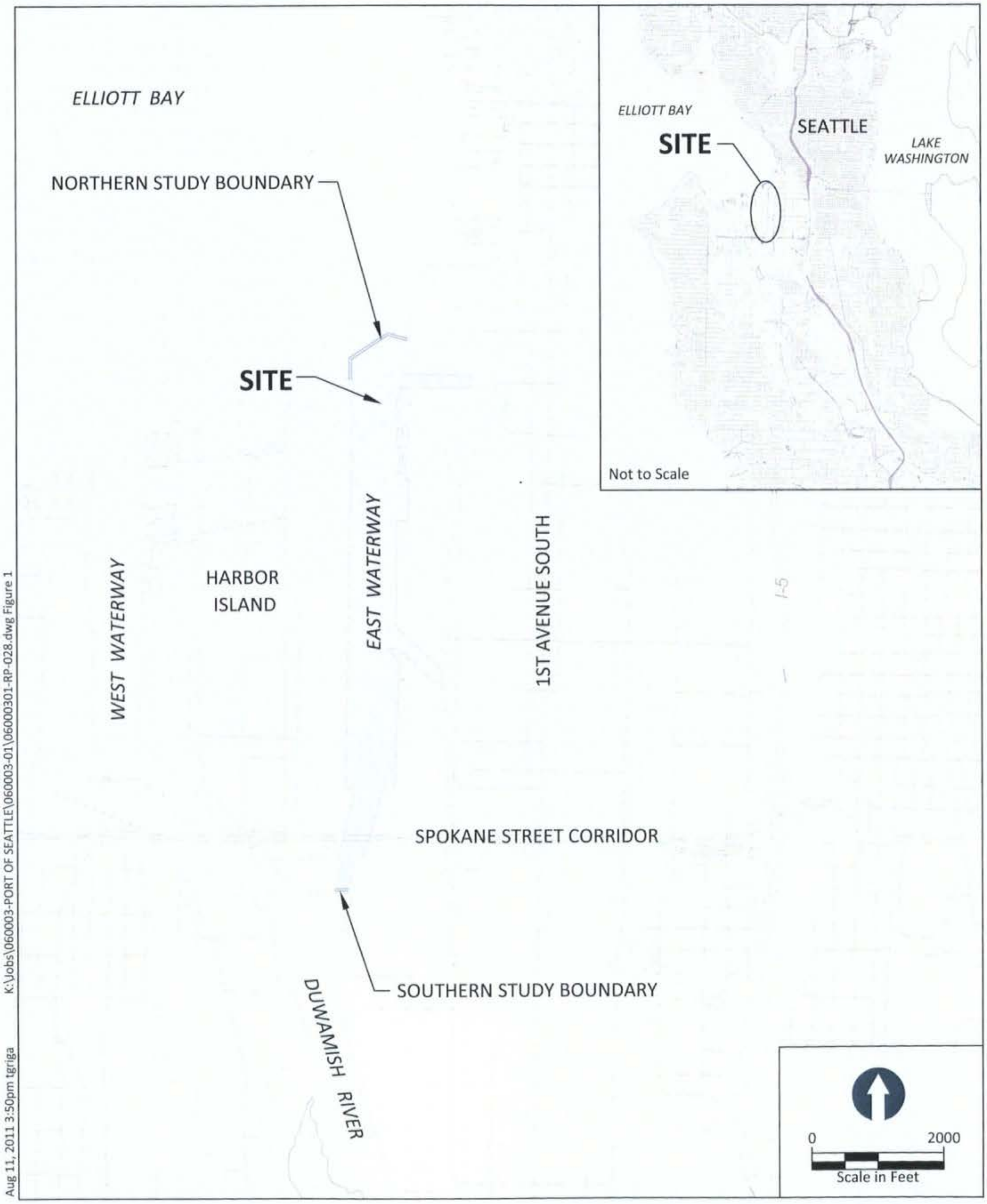
Windward, 2011a. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Appendix A: Draft Baseline Ecological Risk Assessment. Windward Environmental LLC, Seattle, WA. February 25.

Windward, 2011b. East Waterway Operational Unit, Supplemental Remedial Investigation/Feasibility Study, Final Data Report: Subsurface Sediment Sampling For Chemical Analyses. Windward Environmental LLC, Seattle, WA. April.

Windward, 2011c. East Waterway Operable Unit, Supplemental Remedial Investigation/Feasibility Study, Appendix B: Draft Baseline Human Health Risk Assessment. Windward Environmental LLC, Seattle, WA. February 11.

Figures

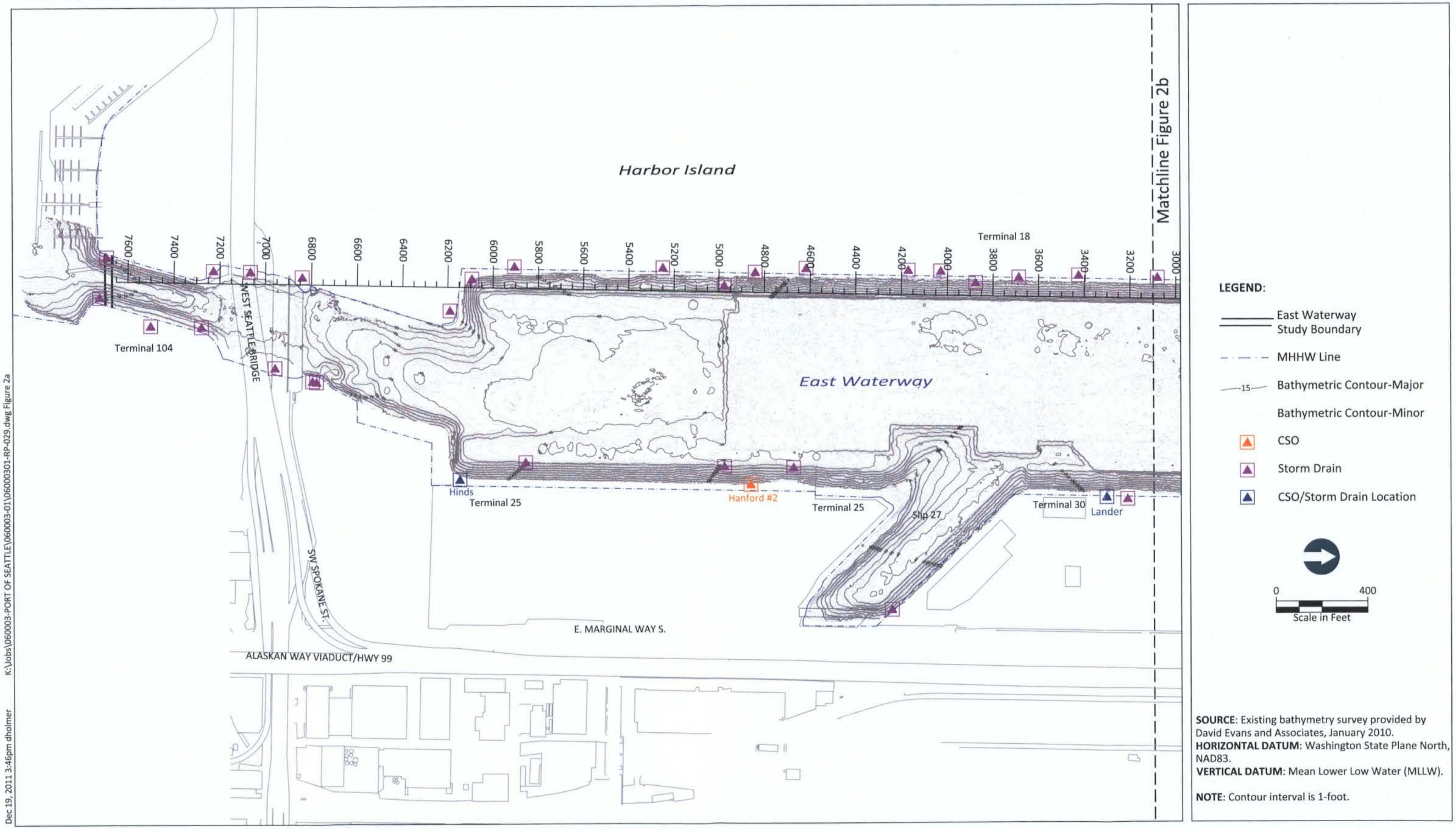
FIGURES



Aug 11, 2011 3:50pm tgriga K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-028.dwg Figure 1

ANCHOR QEA

Figure 1
Vicinity Map and East Waterway Study Boundary
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



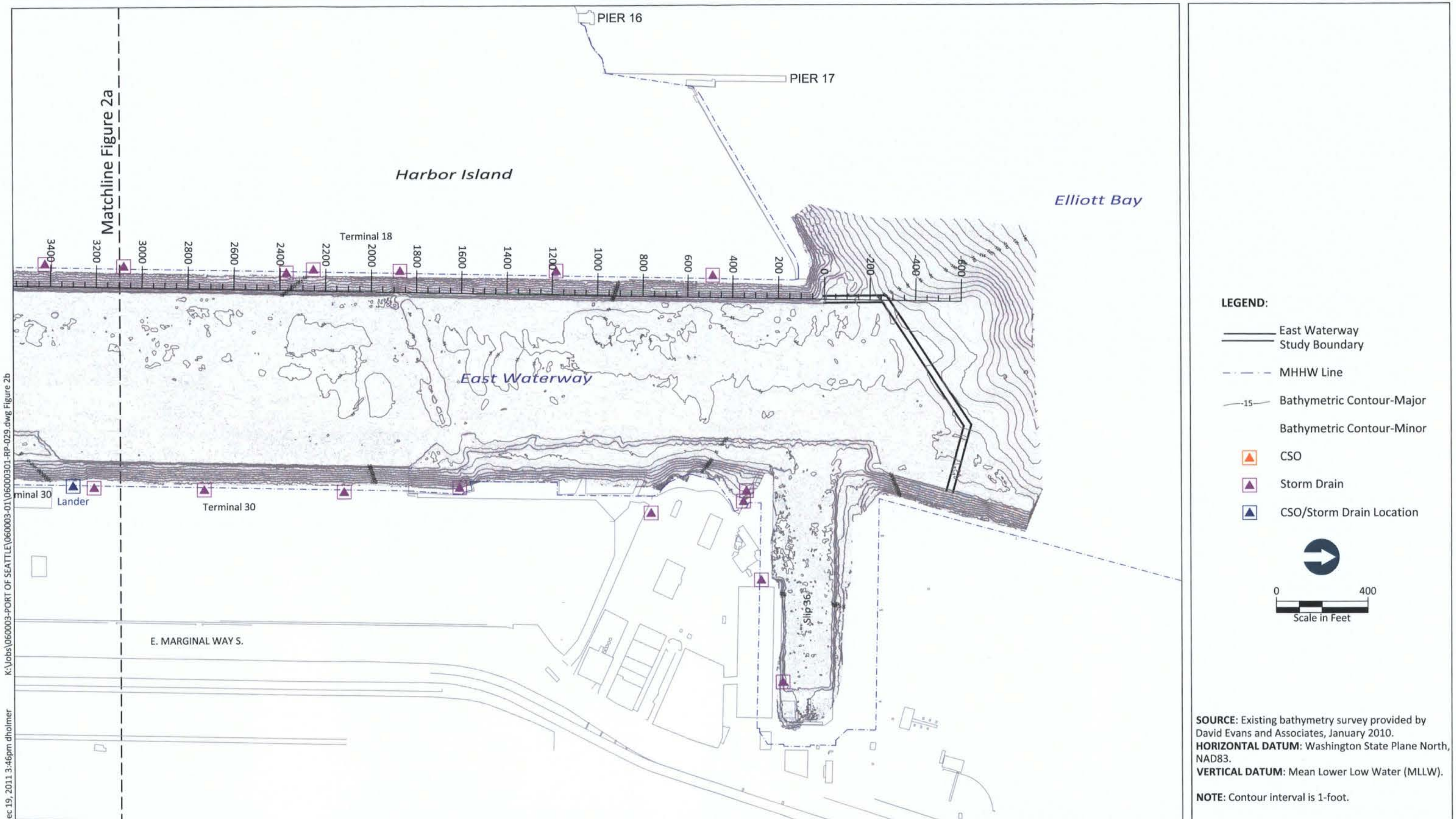
SOURCE: Existing bathymetry survey provided by David Evans and Associates, January 2010.
HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTE: Contour interval is 1-foot.

K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-029.dwg Figure 2a
Dec 19, 2011 3:46pm dholmer

ANCHOR QEA

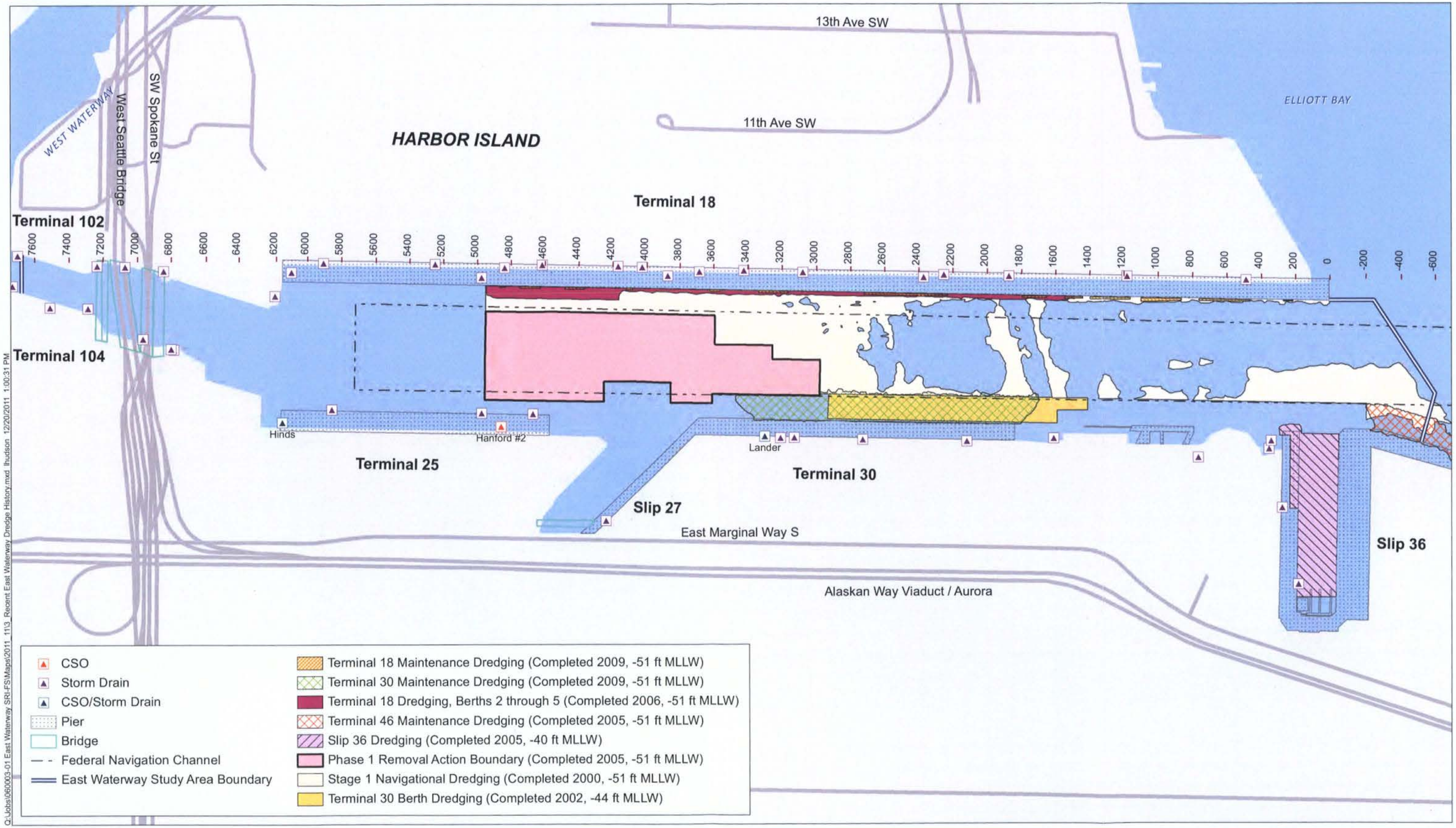
Figure 2a
Existing Bathymetry
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-029.dwg Figure 2b
Dec 19, 2011 3:46pm dholmer

ANCHOR QEA

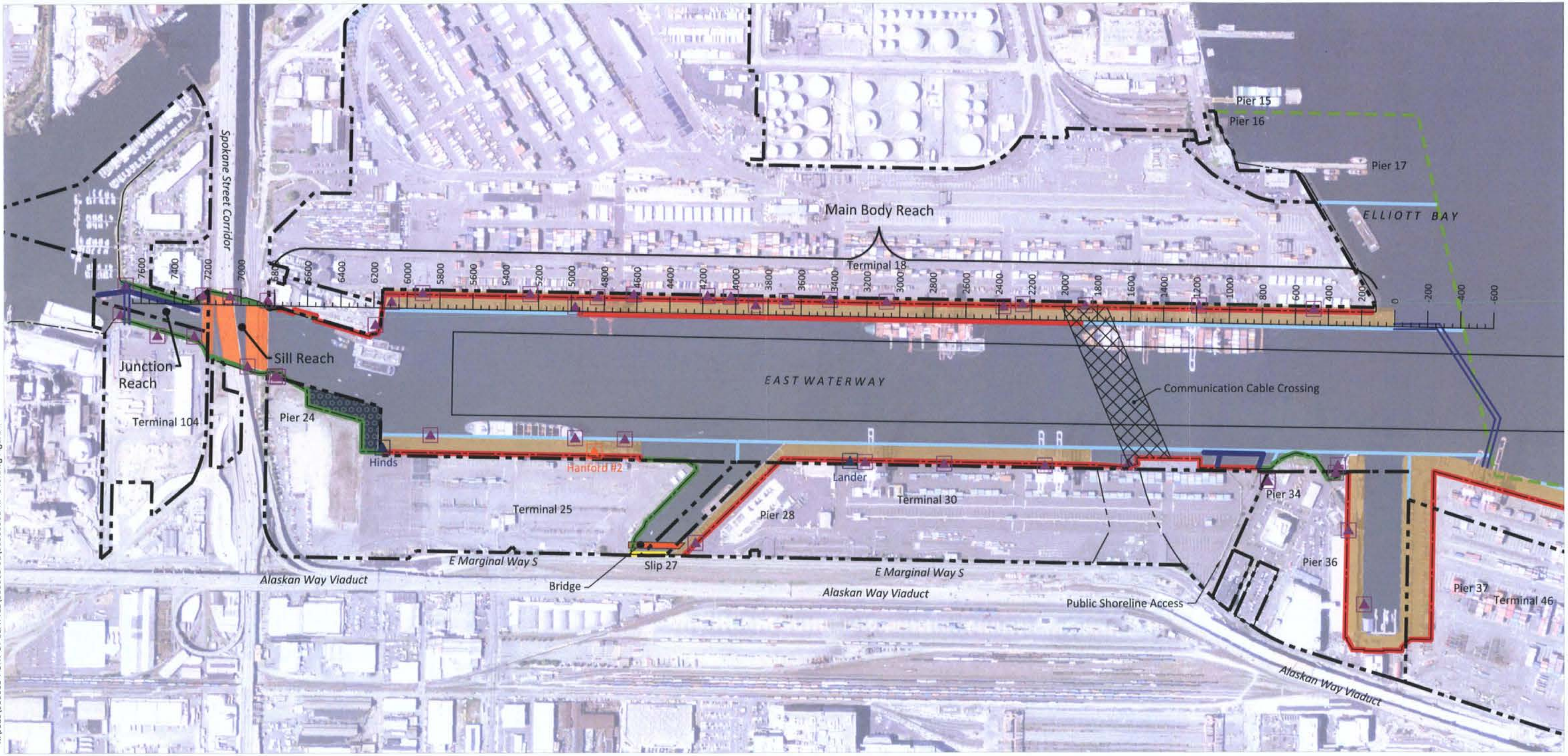
Figure 2b
Existing Bathymetry
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



ANCHOR QEA

NOTE
Previously established station locations for the East Waterway are shown along the western shoreline for reference.

Figure 3
Recent East Waterway Dredge History
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



NOTES:
1. Previously established station locations for the East Waterway are shown along the western shoreline for reference.
2. Values along Westside of East Waterway are station reference values.
3. Aerial photo, NAIP 2011.

LEGEND:
Property Line
East Waterway Study Boundary
MHHW Line
Pierhead Line
Outer Harbor Line
Piling Field
Sheetpile Wall
Exposed Riprap
Overwater Pier Above Riprap
Concrete or Timber Bulkhead
Bridge
Timber Dock
CSO
Storm Drain
CSO/Storm Drain Location

0 600
Scale in Feet

ANCHOR QEA

Figure 4
Major East Waterway Features
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

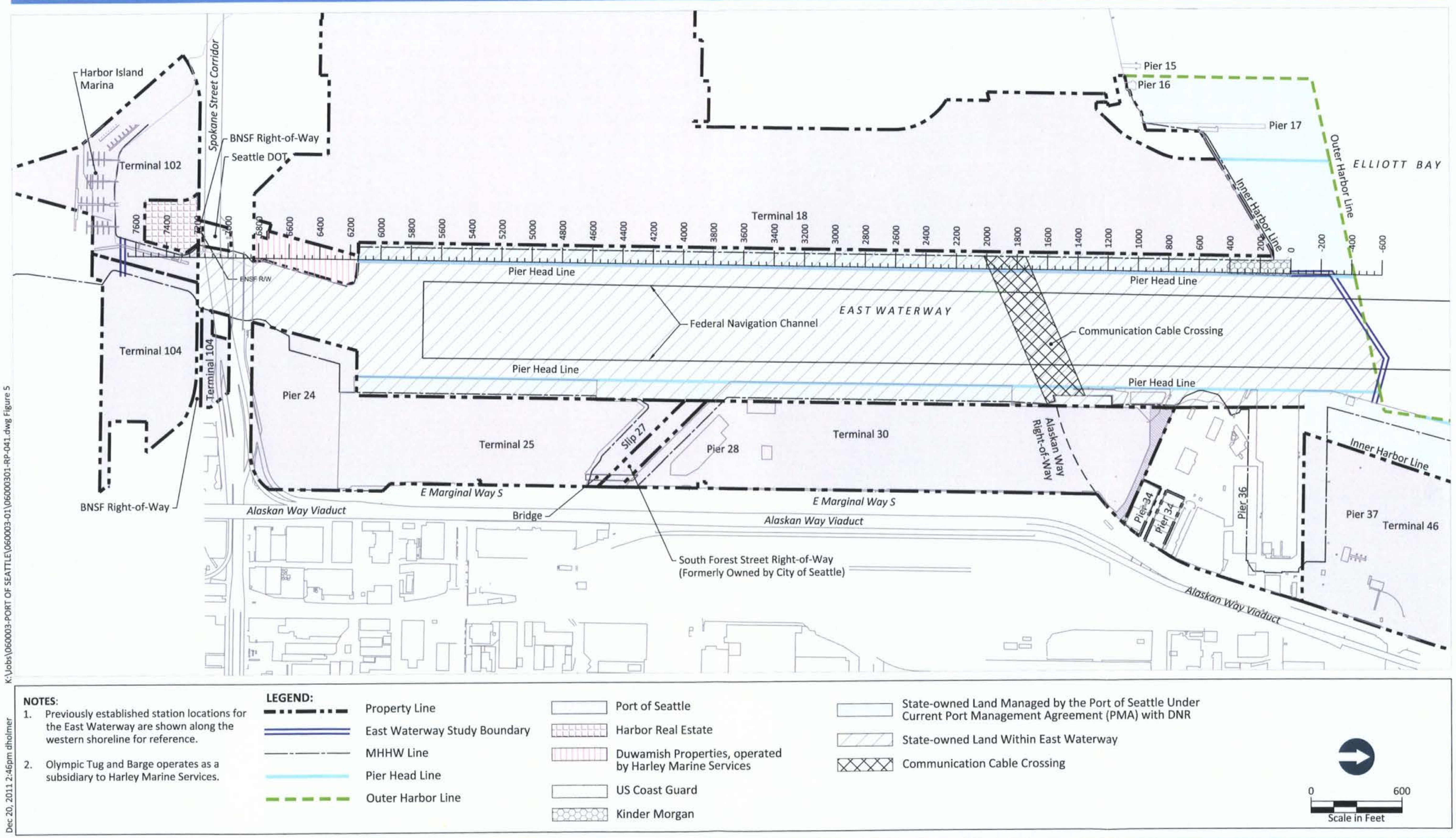
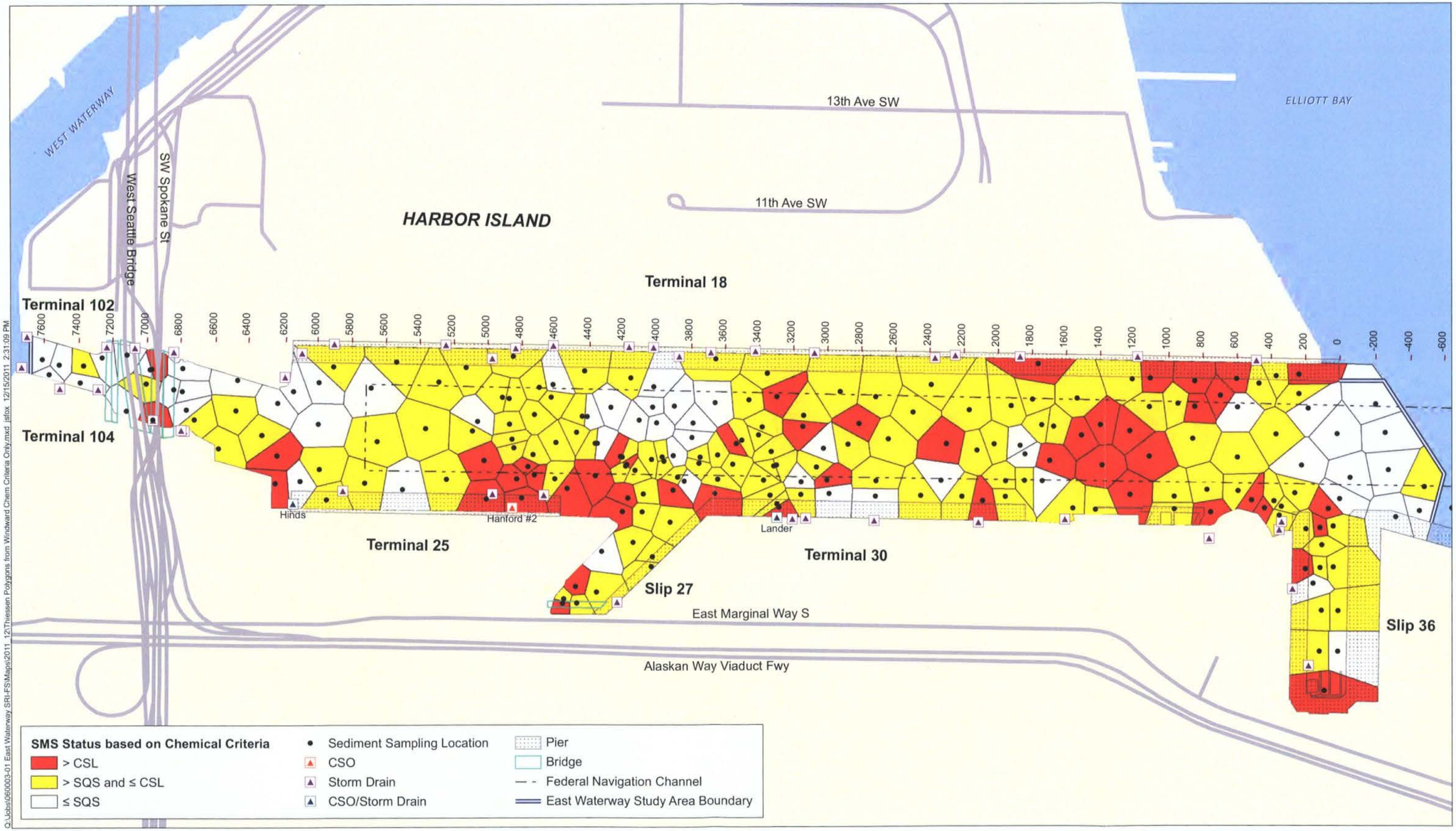


Figure 5
Upland and Aquatic Ownership
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

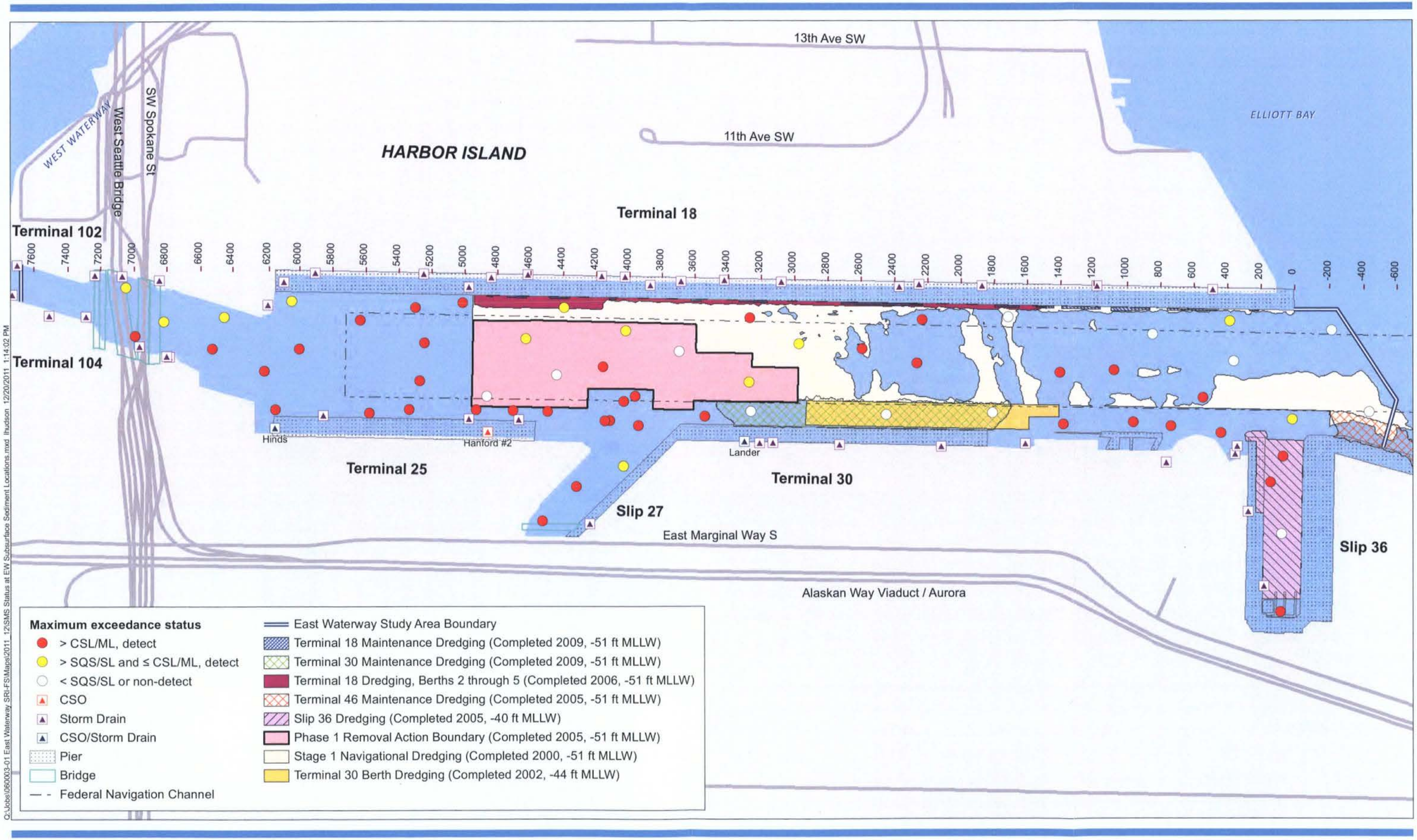
ANCHOR QEA



ANCHOR QEA

Feet
0 270 540 810 1,080

Figure 6
Chemistry Comparison to SMS using Thiessen Polygons for the Baseline Surface Sediment Data Set
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

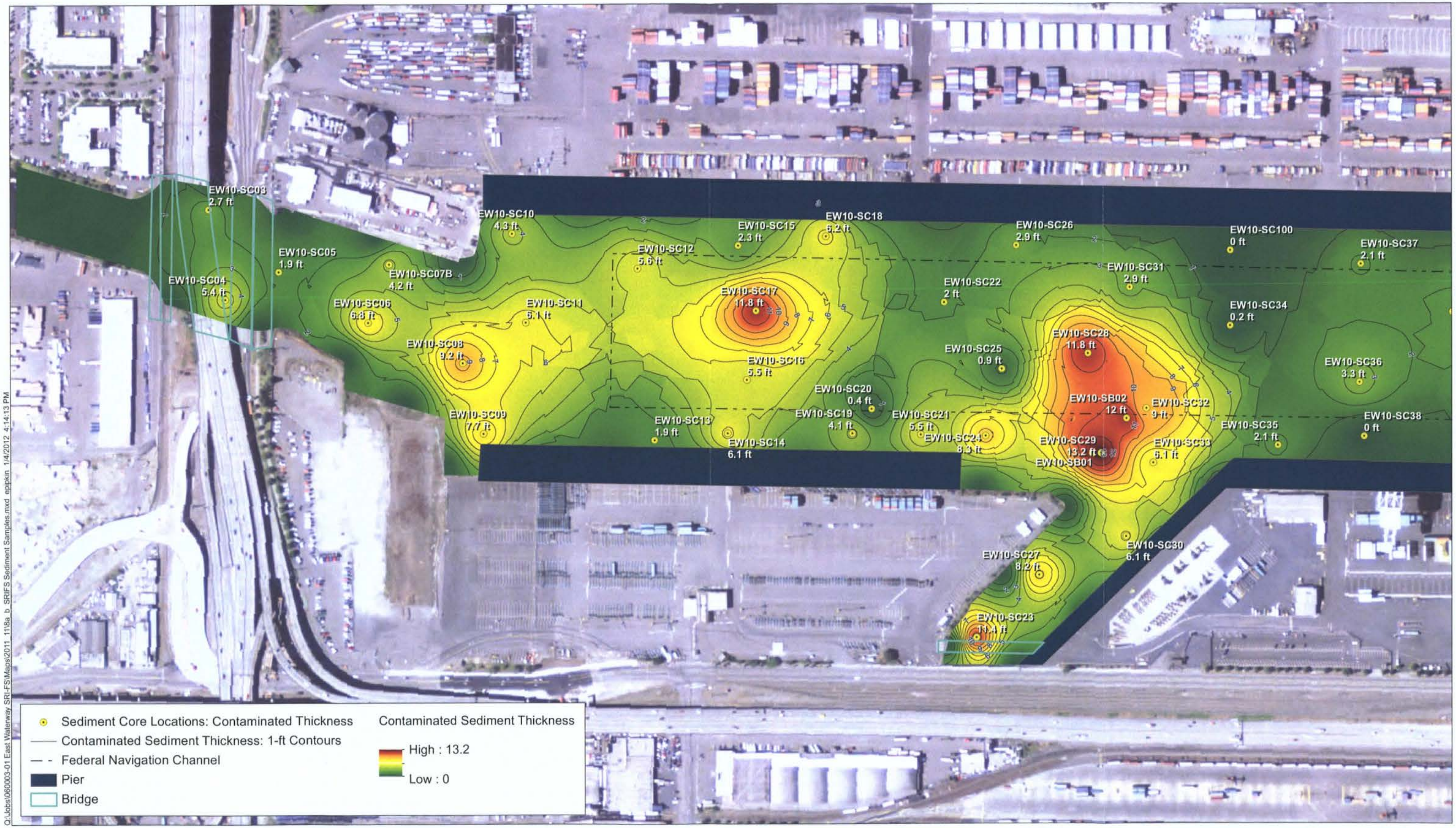


ANCHOR QEA

NOTES

1. Previously established station locations for the East Waterway are shown along the western shoreline for reference.
2. Sampling locations are colored according to the maximum exceedance in a sediment core. Thicknesses of sediment exceeding SQS and CSL are provided in Appendix A.
3. Exceedances in previously-dredged areas represent post-dredge conditions.
4. Only cores collected in 2010 are shown.

Figure 7
SMS Status at East Waterway Subsurface Sediment Sampling Locations
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



O:\Jobs\060003-01 East Waterway SRI-FS\Maps\2011 11\8a_b_SRIFS Sediment Samples.mxd epipkin 1/4/2012 4:14:13 PM

NOTES
1. Contaminated thickness of SB-01 not included in IDW interpolation. Contaminated volumes of the mound area will be developed separately.
2. Underpier areas have been blocked out because sediment cores are not available in those areas, and the interpolated contaminated thickness/elevation is not accurate.
3. Only cores collected in 2010 are shown.
4. Aerial photo, NAIP 2011.

Feet
0 150 300 450 600

ANCHOR QEA

Figure 8a
Thickness of Sediment Above SQS
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Q:\Jobs\060003-01 East Waterway SRI-FS\Maps\2011 11\8a_b SRIFS Sediment Samples.mxd epipkin 1/4/2012 4:05:24 PM

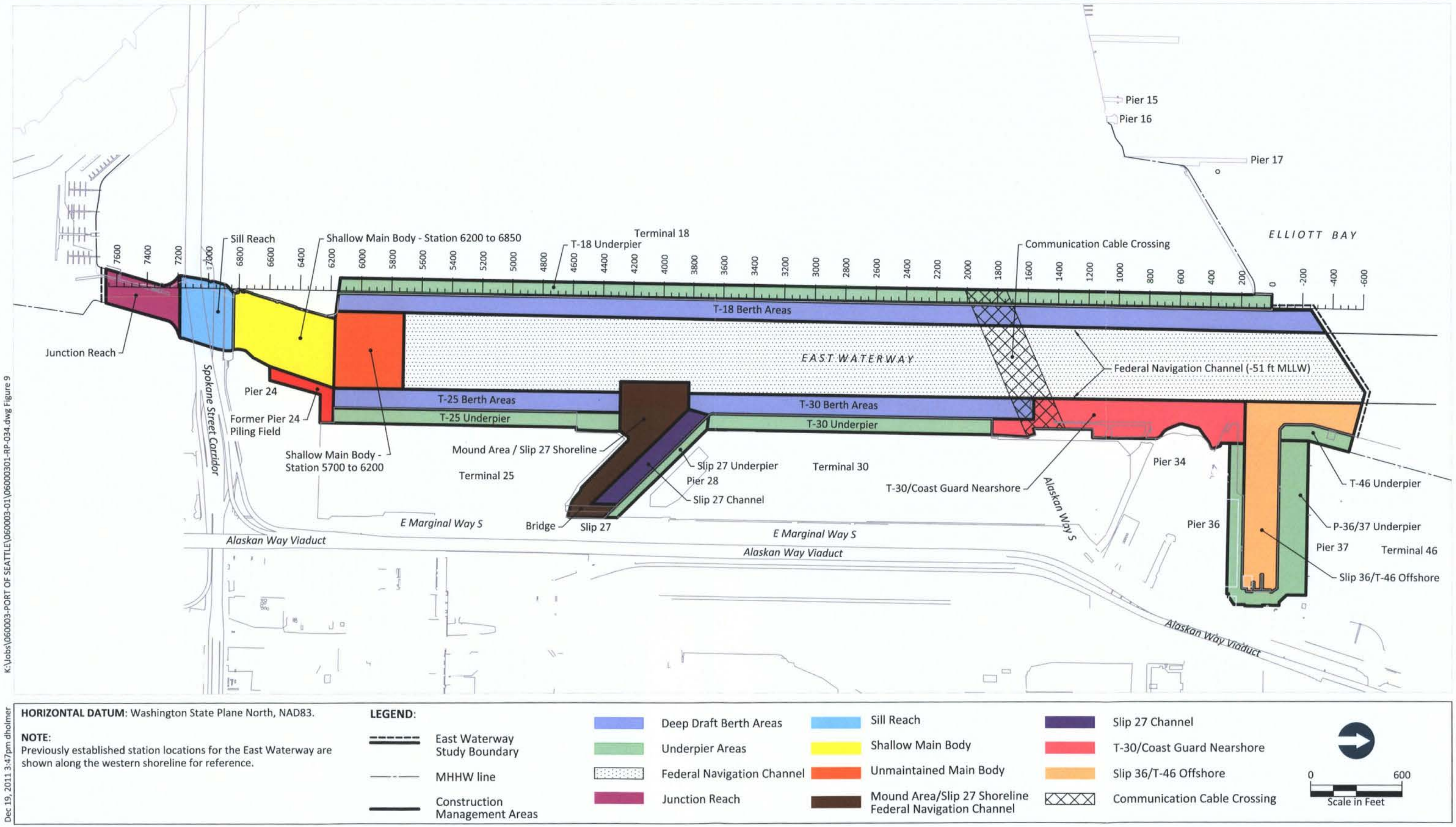
ANCHOR QEA

NOTES

1. Contaminated thickness of SB-01 not included in IDW interpolation. Contaminated volumes of the mound area will be developed separately.
2. Underpier areas have been blocked out because sediment cores are not available in those areas, and the interpolated contaminated thickness/elevation is not accurate.
3. Only cores collected in 2010 are shown.
4. Aerial photo, NAIP 2011.

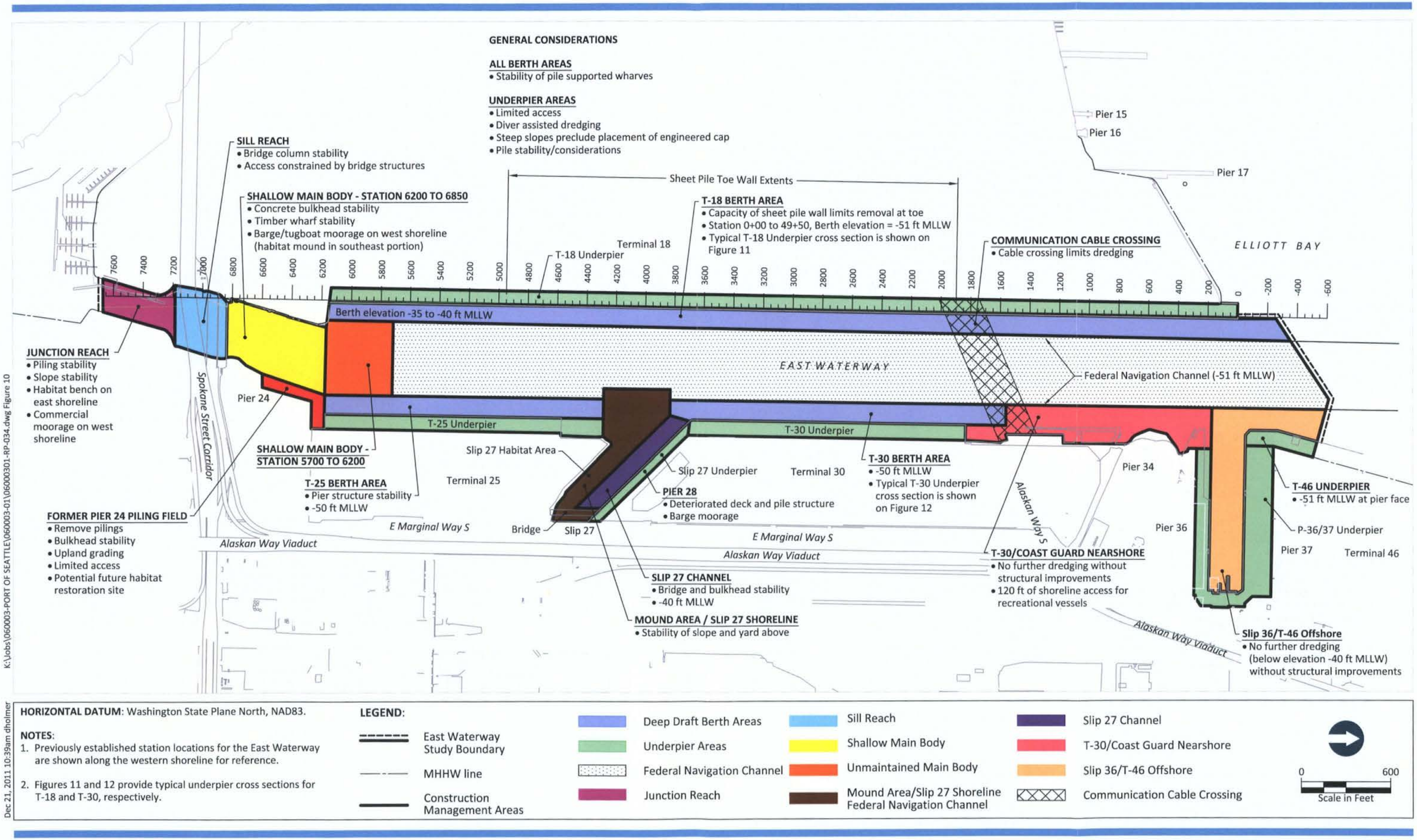
Feet
0 150 300 450 600

Figure 8b
Thickness of Sediment Above SQS
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



ANCHOR QEA

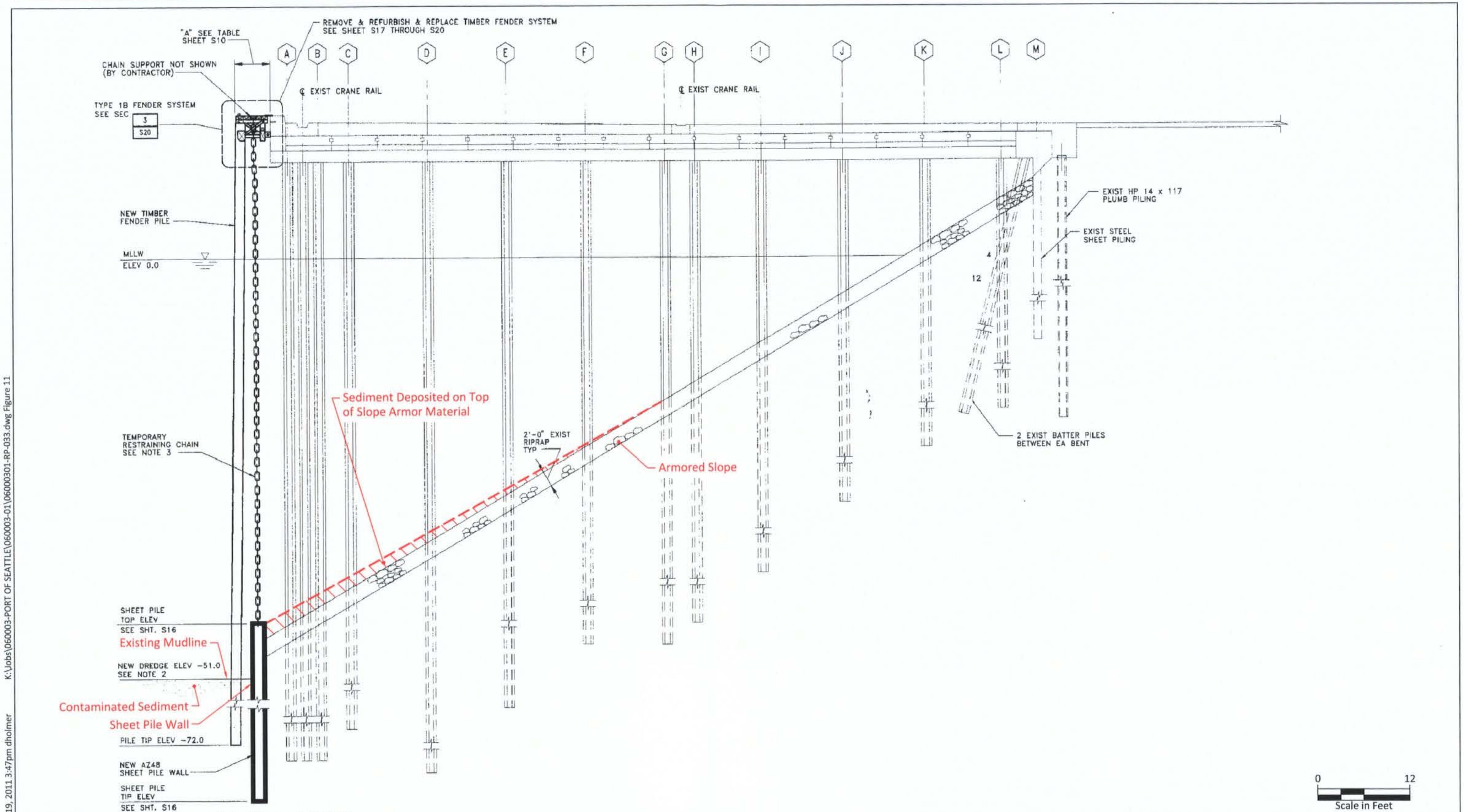
Figure 9
Construction Management Areas
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-034.dwg Figure 10
Dec 21, 2011 10:39am dholmer

ANCHOR QEA

Figure 10
Critical Site Restrictions by Construction Management Area
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

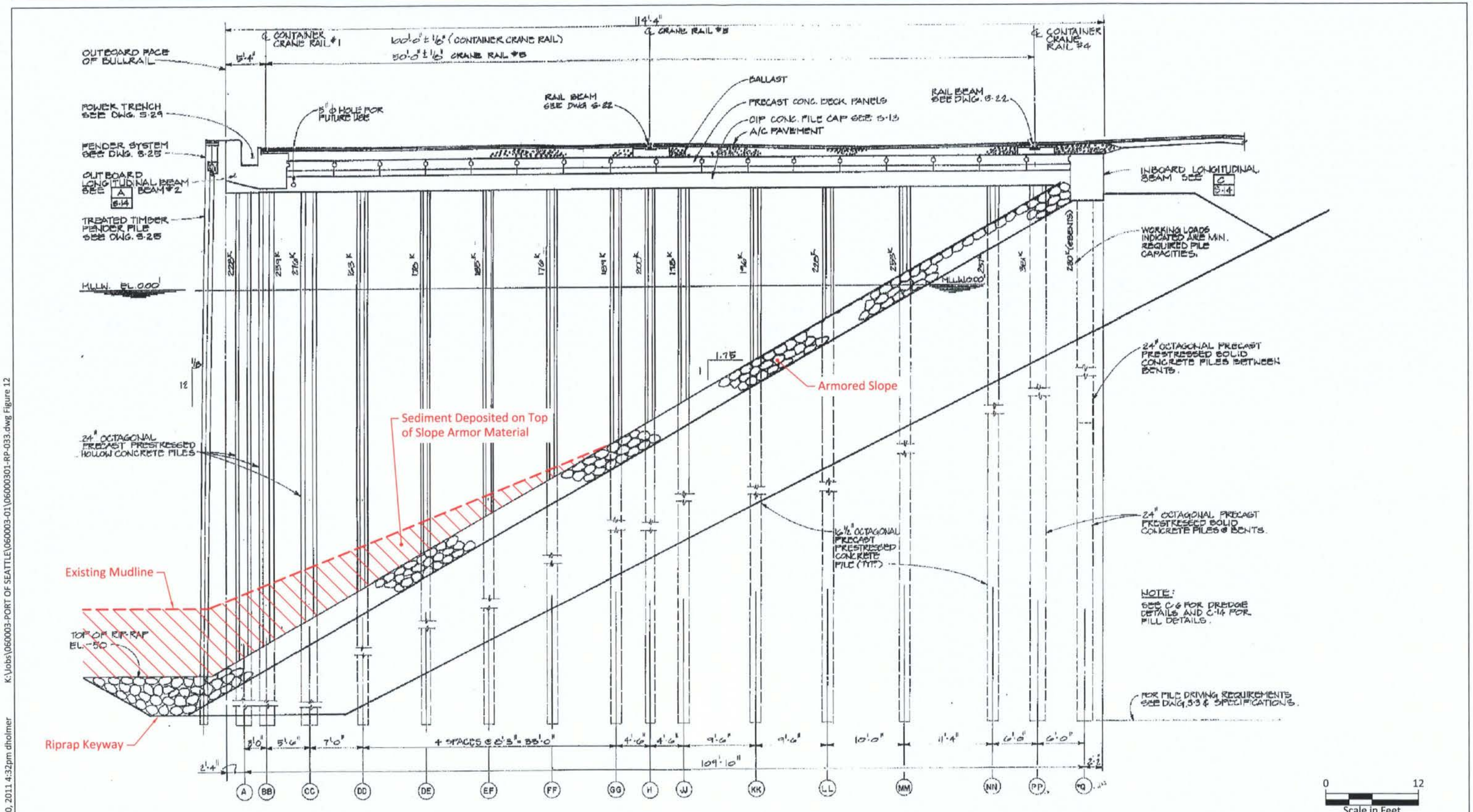


NOTE: Drawing prepared from electronic file by KPFF dated 2/21/2005.

Dec 19, 2011 3:47pm dholmer K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-033.dwg Figure 11

ANCHOR QEA

Figure 11
Typical Cross Section of Terminal 18 Sheetpile Toe Wall
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



NOTE: Drawing prepared from electronic file by KPFF dated 7/09/1985.

Dec 20, 2011 4:32pm dholmer K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-033.dwg Figure 12

ANCHOR QEA

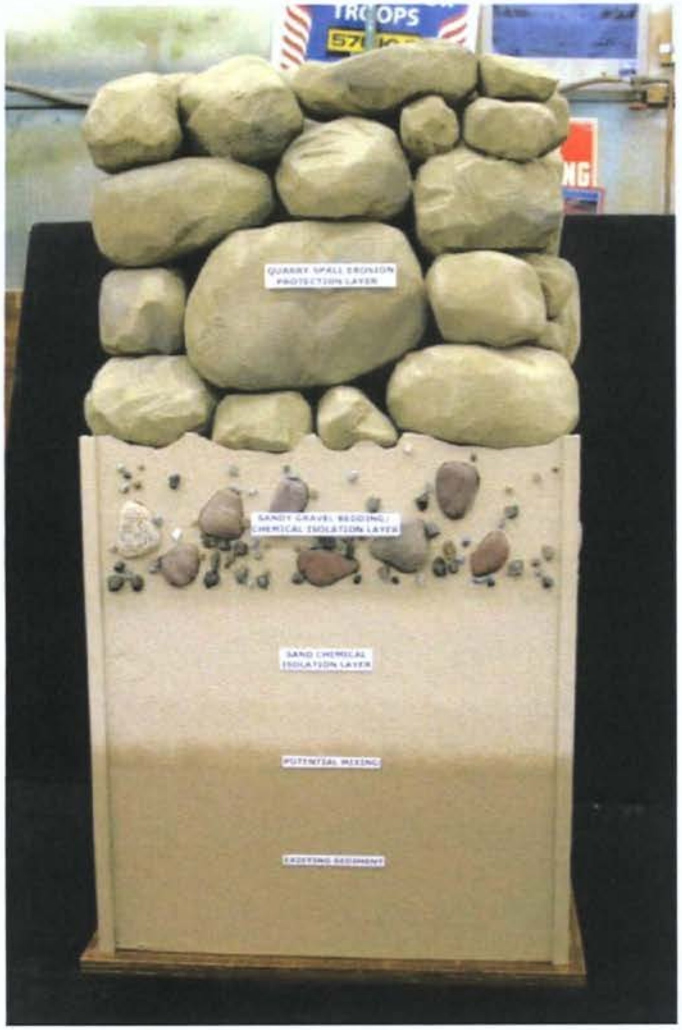
Figure 12
Typical Cross Section of Terminal 25 and 30
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Hydraulic Spray Placement at Eagle Harbor, Washington

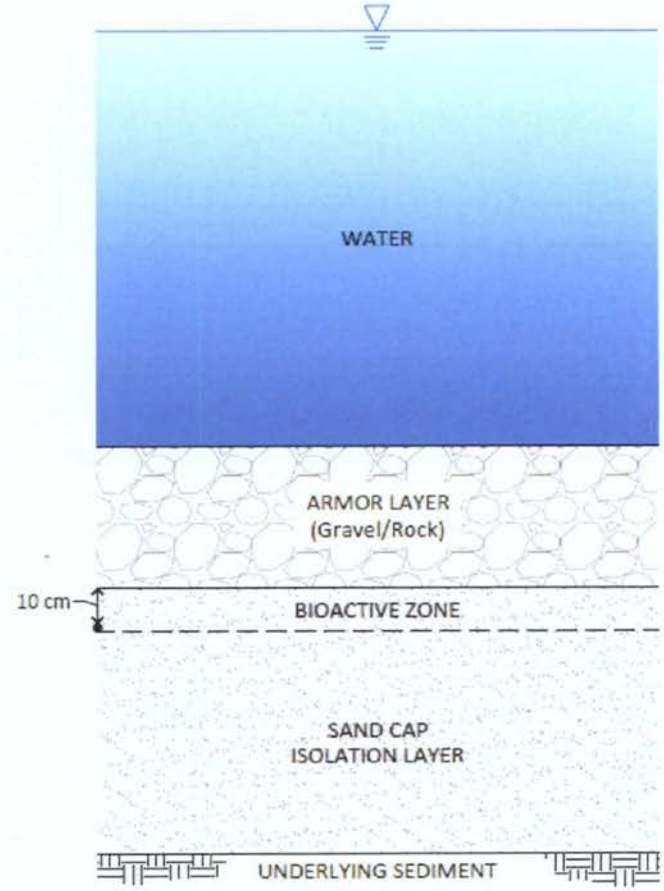
Conveyor Placement of Thin Layer Cap

ANCHOR QEA

Figure 13
Enhanced Natural Recovery Example Placement Methods
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



Model of Typical Armored Engineered Cap Cross Section



Cross Section of Typical Armored Engineered Cap

ANCHOR QEA

Figure 14
Armored Engineered Cap Cross Sections
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Cap Placement Using Bucket

Cap Placement Using Tremie and Conveyor

Armor Rock Placement with Skip Box

ANCHOR QEA

Figure 15
Cap Placement Methods
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Housatonic River, Massachusetts

East Waterway Phase 1 Removal Action Dredging, Seattle,WA

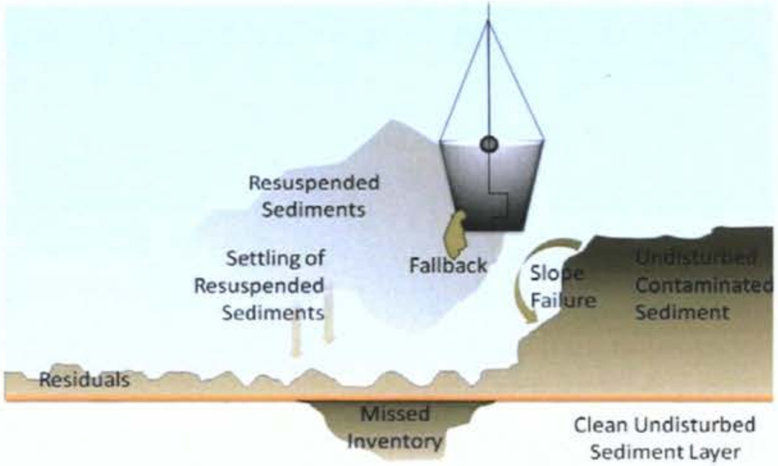
Mechanical Clamshell Dredge

Hydraulic Cutterhead Dredge with Pipeline on Pontoons

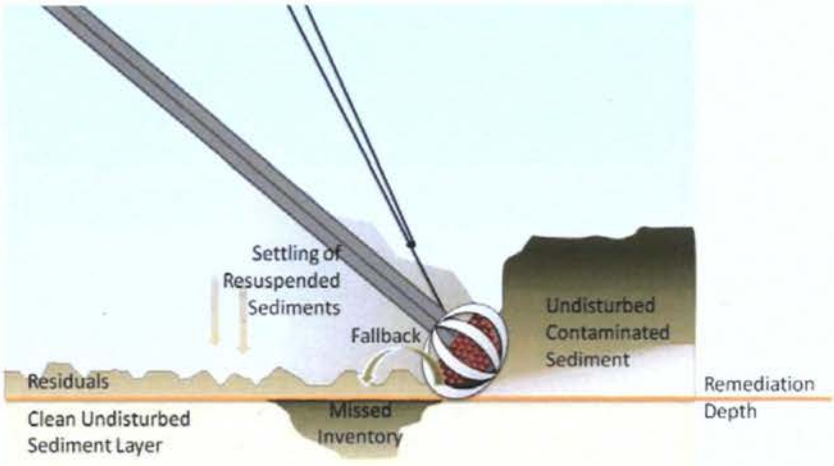
Diver-Assisted Suction Dredge (photo shows nozzle of hose)

ANCHOR
QEA

Figure 17
Dredging Technologies
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

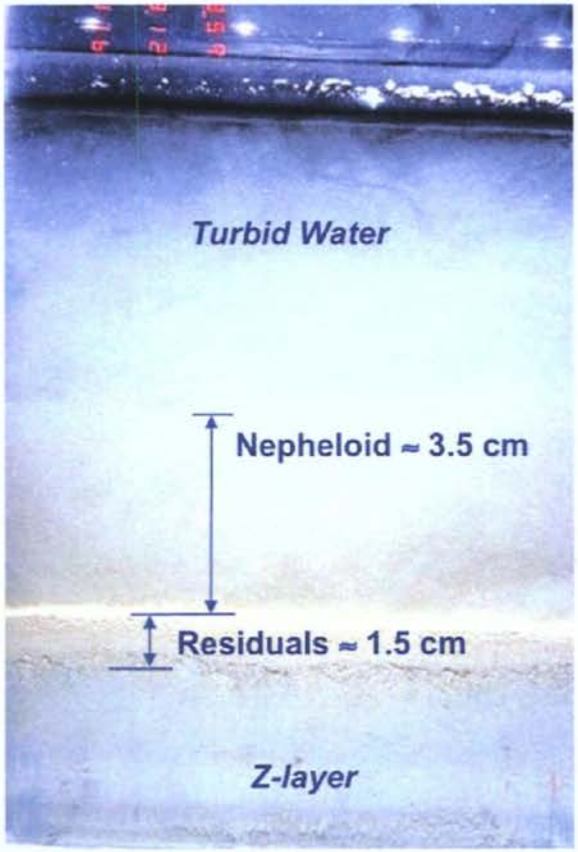


Mechanical Dredging

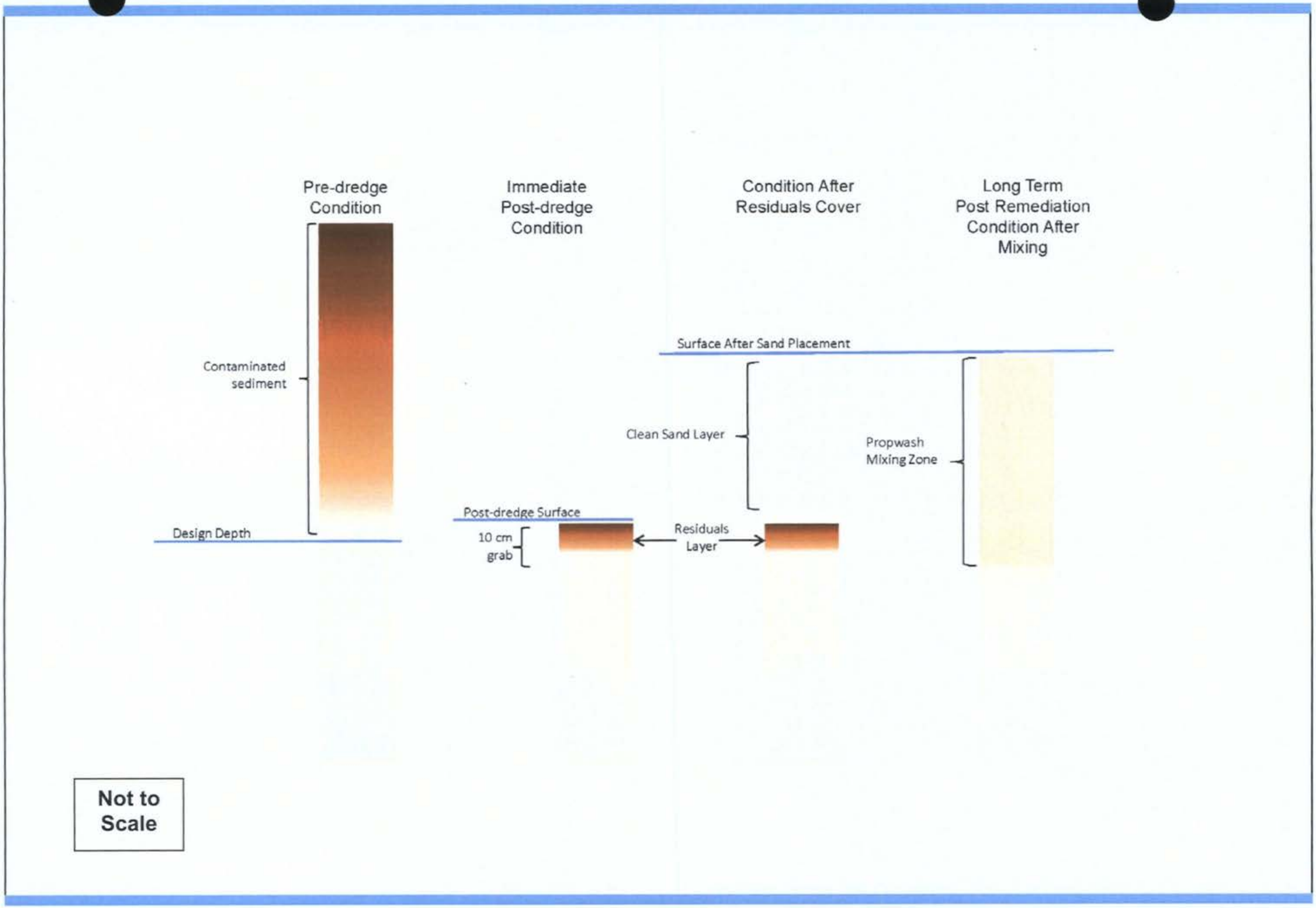


Hydraulic Dredging

Residuals Generation Processes



Sediment Profile Image showing Residual Layer



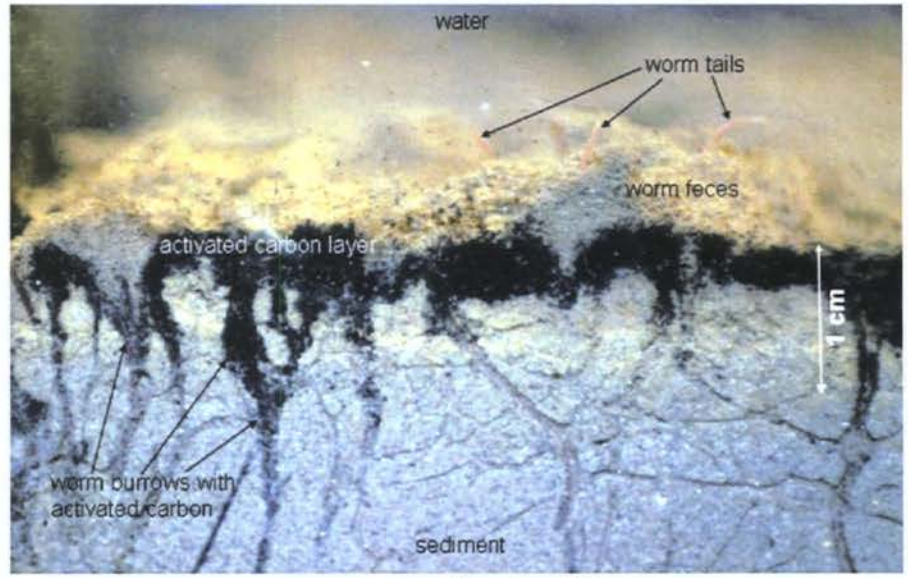
ANCHOR QEA

Figure 19
Conceptual Residuals Management Strategy
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

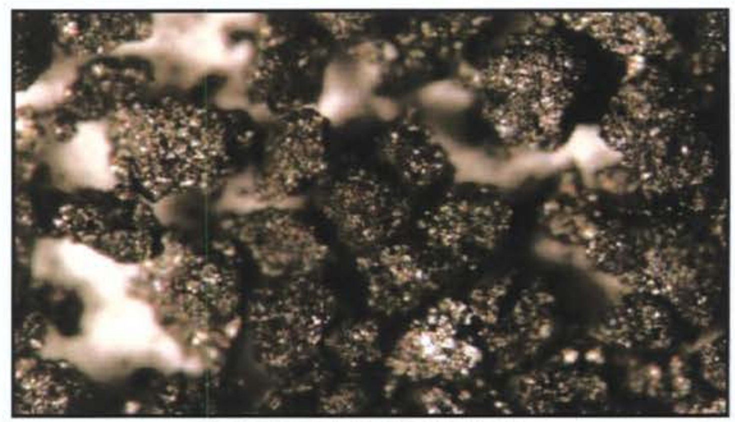
East Waterway Phase 1 Removal Action, Seattle, Washington

Figure 20
Offloading and Staging of Dredged Sediment
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Sediment core containing GAC



Sediment profile with GAC



Granulated Activated Carbon

Figure 21
In-Situ Treatment– GAC
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Dec 01, 2011 3:14pm dholmer K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-035.dwg Figure 22

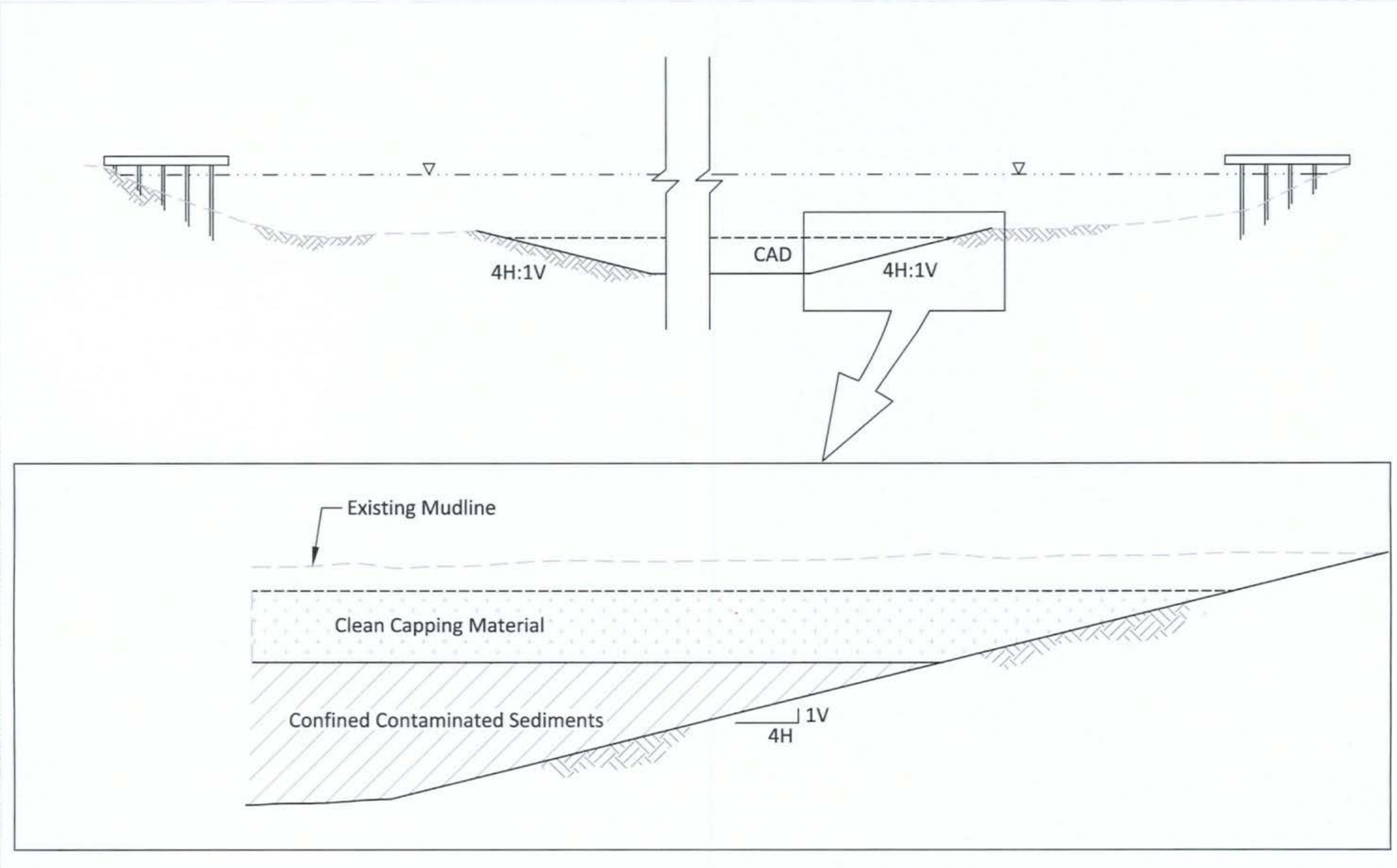
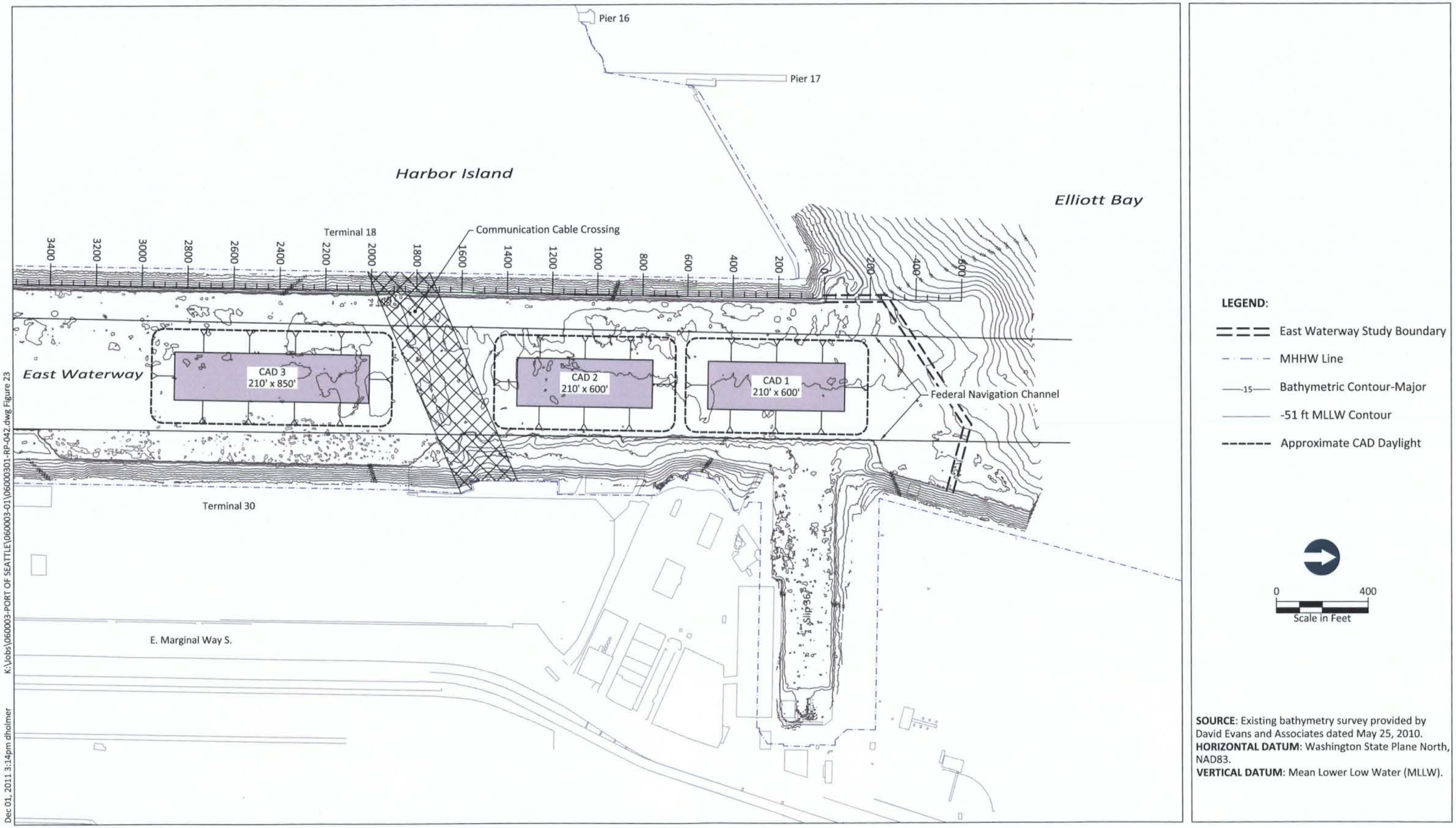


Figure 22
Conceptual Cross Section Illustrating Confined Aquatic Disposal (CAD)
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

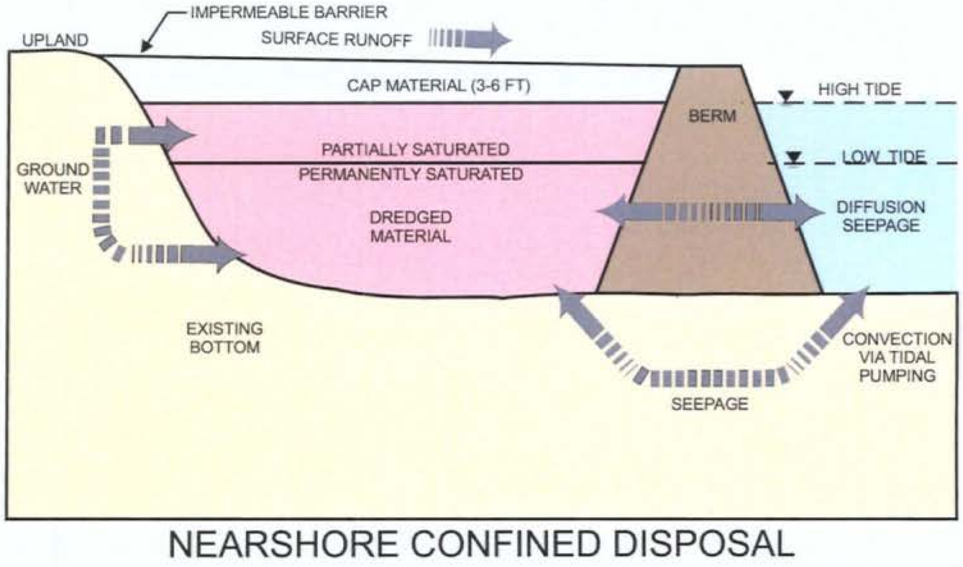
ANCHOR QEA



ANCHOR QEA

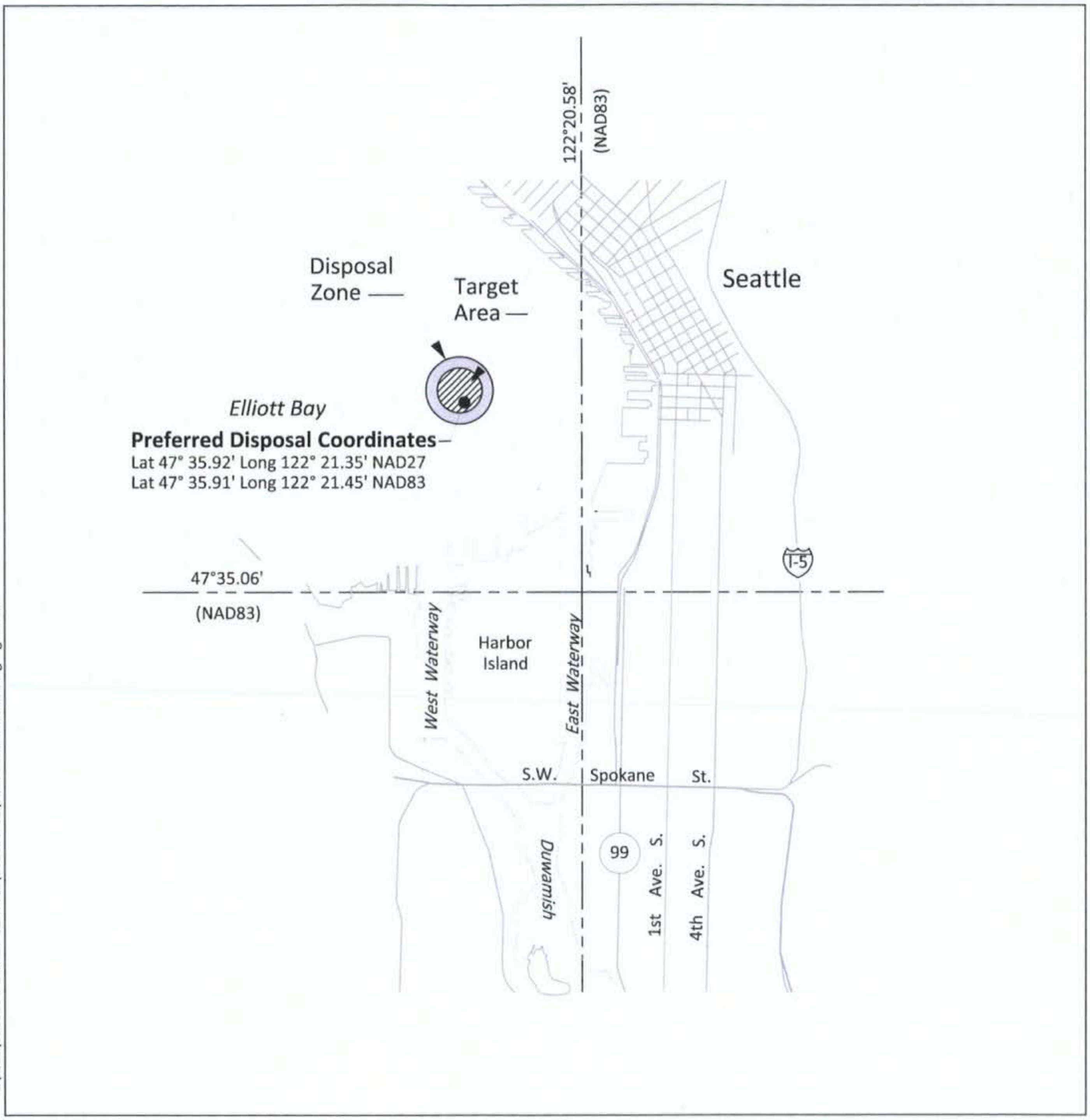
Figure 23
East Waterway Conceptual CAD Design
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

Port of Tacoma Milwaukee Waterway NCDF (during construction)



NCDF Contaminant Pathways

Figure 24
Example Nearshore Confined Disposal Facility
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-036.dwg Figure 25

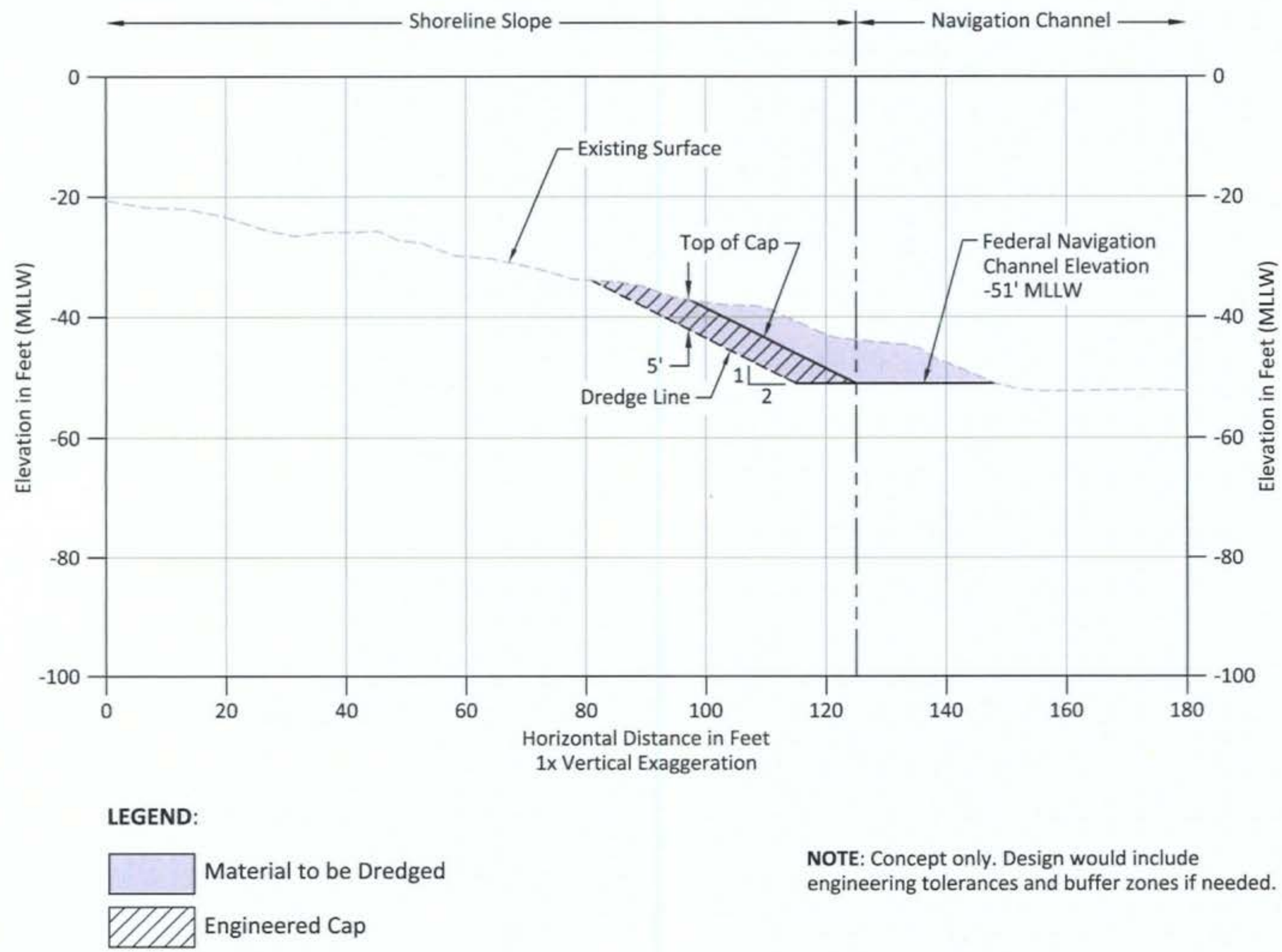
Dec 01, 2011 3:14pm dholmer

SOURCE: U.S. Army Corps of Engineeers.
ELLIOTT BAY DISPOSAL SITE:
TYPE: Nondispersive.
AREA: 415 Acres.
DEPTH: 300'-360'
SITE DIMENSIONS: 6200' by 4000' Ovoid.
DISPOSAL ZONE: 1800' Diameter.
TARGET AREA: 1200' Diameter.
BARGE POSITIONING METHOD: VTS.

0 4000
Scale in Feet

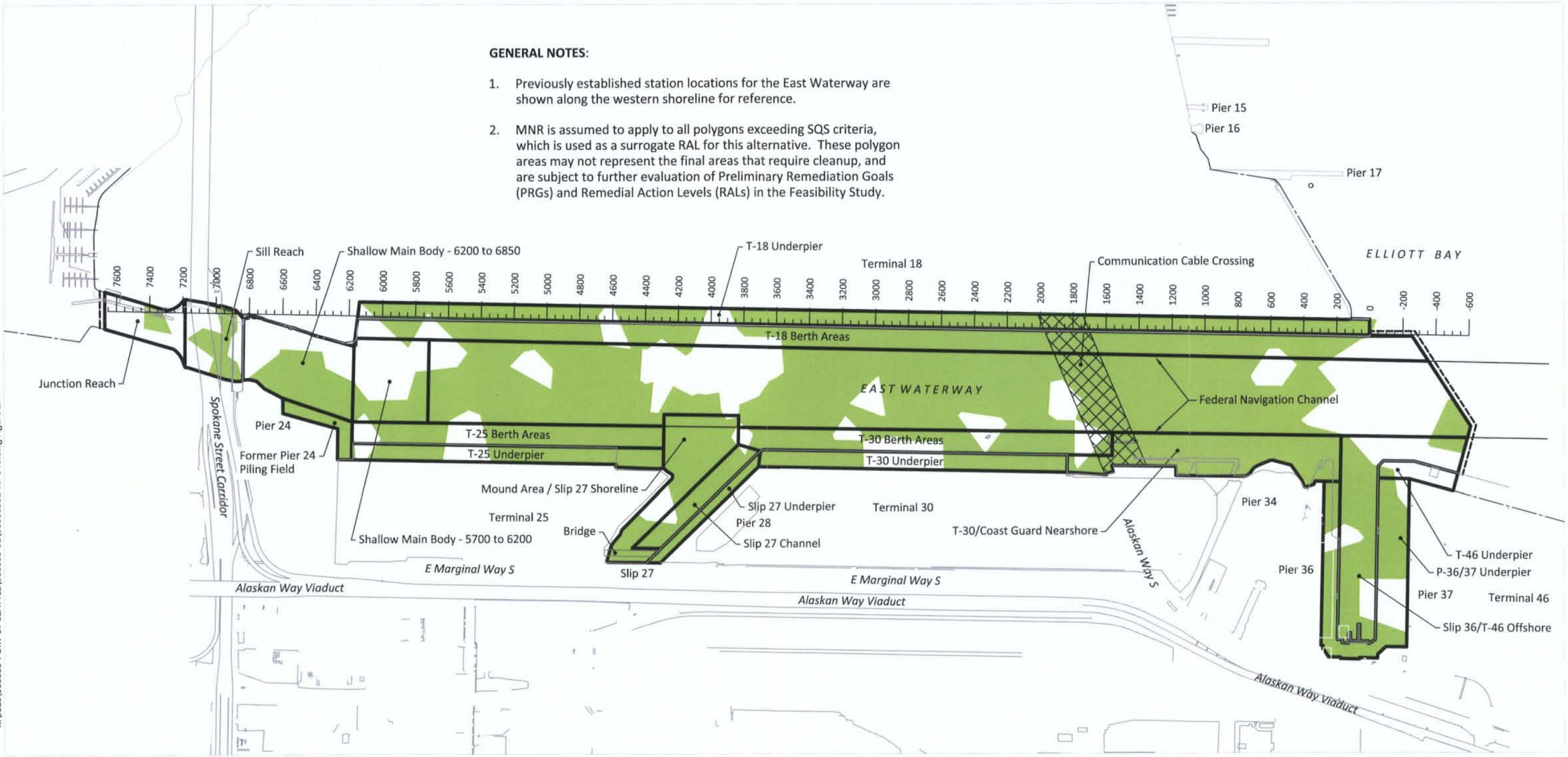
Figure 25
Open Water Disposal Site Map
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

ANCHOR QEA



ANCHOR QEA

Figure 26
Conceptual Cross Section of Mound Area/Slip 27 Shoreline and T-30/Coast Guard Nearshore
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-043.dwg Figure 27

Dec 21, 2011 10:39am dholmer

HORIZONTAL DATUM: Washington State Plane North, NAD83, US Survey Feet.

LEGEND:

- East Waterway Study Boundary
- MHHW line
- Construction Management Areas
- No Action (NA)
- Monitored Natural Recovery (MNR)

0 600
Scale in Feet

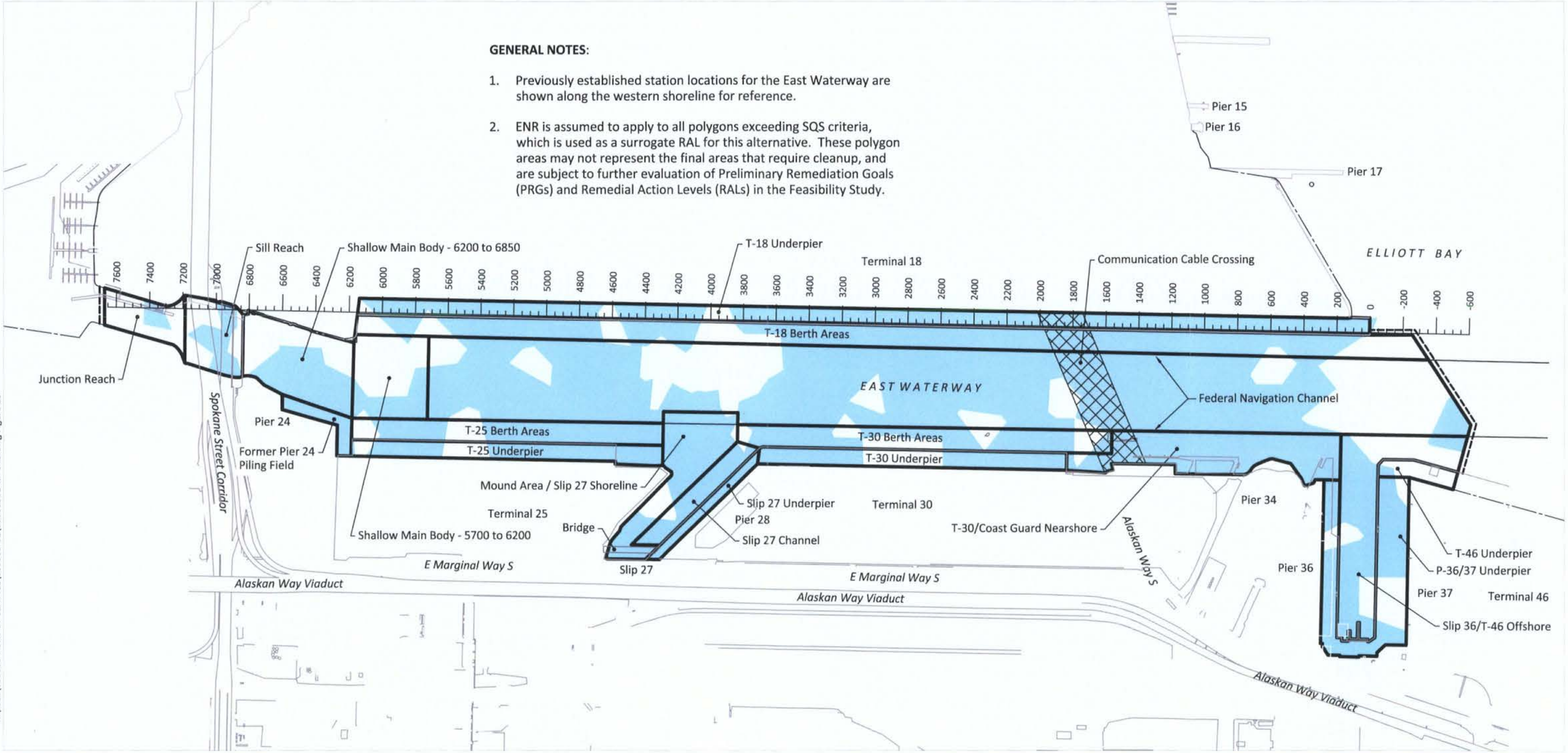
ANCHOR QEA

Figure 27
Alternative B - Monitored Natural Recovery
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

GENERAL NOTES:

1. Previously established station locations for the East Waterway are shown along the western shoreline for reference.

2. ENR is assumed to apply to all polygons exceeding SQS criteria, which is used as a surrogate RAL for this alternative. These polygon areas may not represent the final areas that require cleanup, and are subject to further evaluation of Preliminary Remediation Goals (PRGs) and Remedial Action Levels (RALs) in the Feasibility Study.



HORIZONTAL DATUM: Washington State Plane North, NAD83, US Survey Feet.

LEGEND:

East Waterway Study Boundary

MHHW line

Construction Management Areas

No Action (NA)

Enhanced Natural Recovery (ENR)

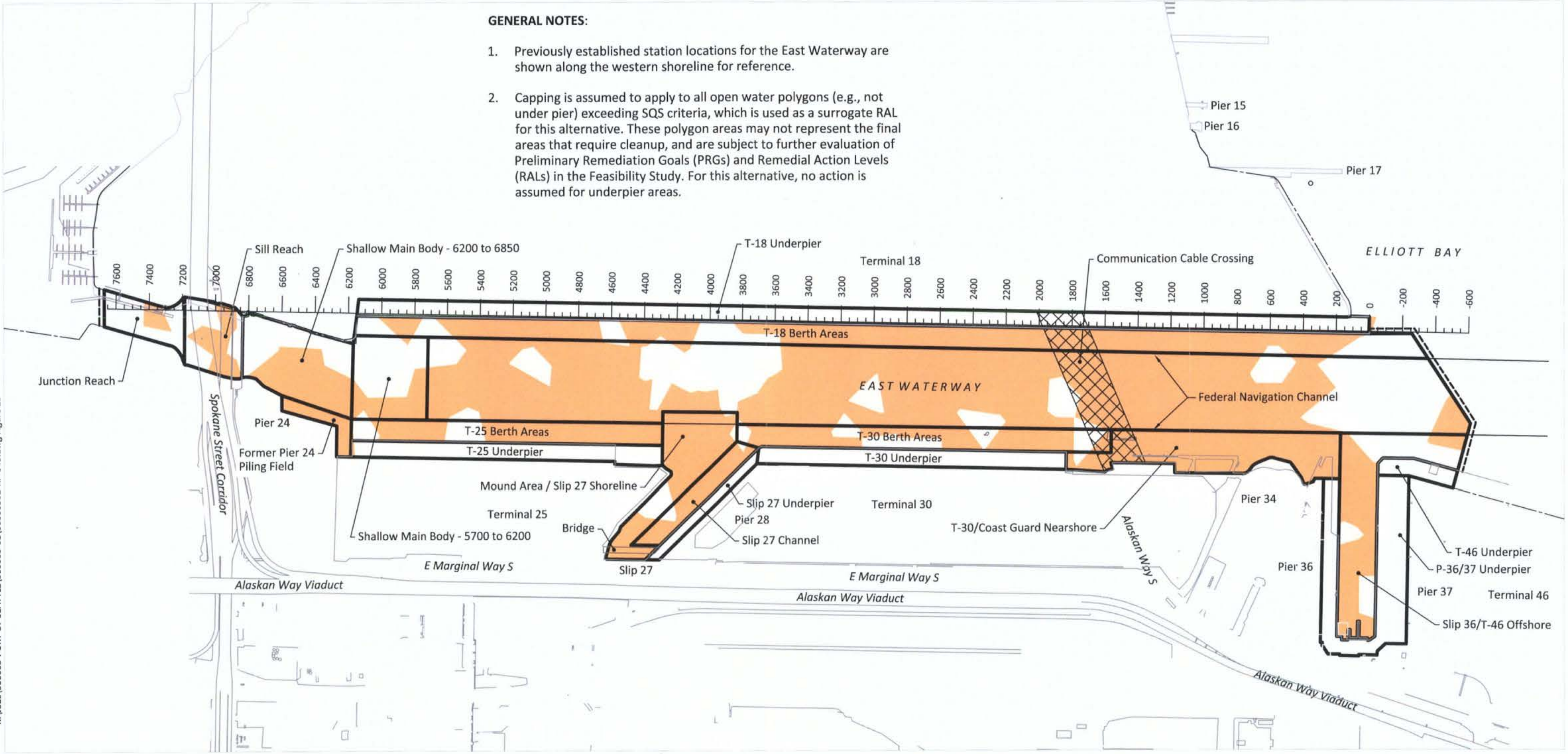
0 600
Scale in Feet

K:\Jobs\060003-PORT OF SEATTLE\060003-01\060003-01-RP-043.dwg Figure 28

Dec 21, 2011 10:39am dholmer

ANCHOR QEA

Figure 28
Alternative C - Enhanced Natural Recovery
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS



HORIZONTAL DATUM: Washington State Plane North, NAD83, US Survey Feet.

LEGEND:

- East Waterway Study Boundary
- MHHW line
- Construction Management Areas
- No Action (NA)
- Containment / Capping

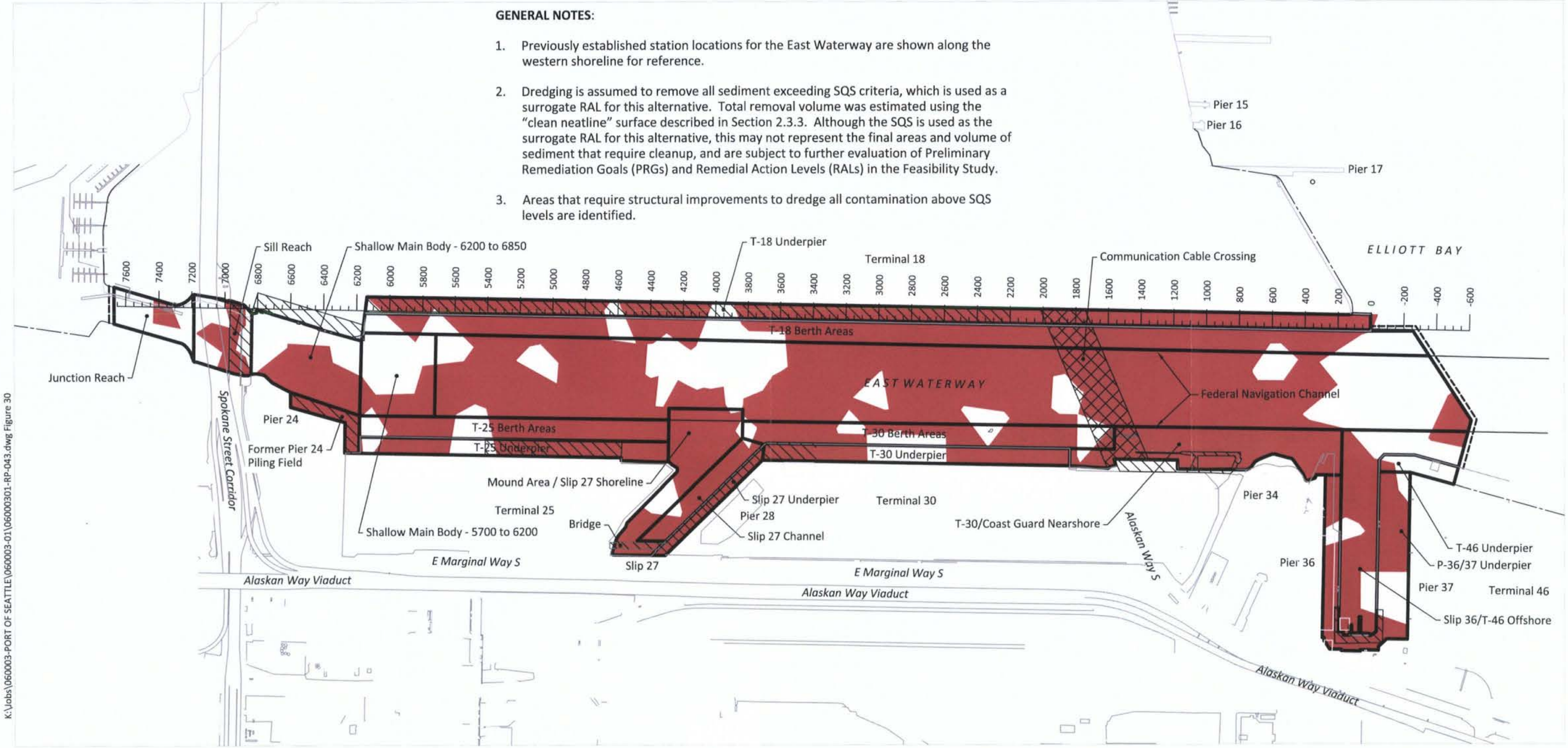
0 600
Scale in Feet

ANCHOR QEA

Figure 29
Alternative D - Cap All Areas Exceeding SQS
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

GENERAL NOTES:

1. Previously established station locations for the East Waterway are shown along the western shoreline for reference.
2. Dredging is assumed to remove all sediment exceeding SQS criteria, which is used as a surrogate RAL for this alternative. Total removal volume was estimated using the "clean neatline" surface described in Section 2.3.3. Although the SQS is used as the surrogate RAL for this alternative, this may not represent the final areas and volume of sediment that require cleanup, and are subject to further evaluation of Preliminary Remediation Goals (PRGs) and Remedial Action Levels (RALs) in the Feasibility Study.
3. Areas that require structural improvements to dredge all contamination above SQS levels are identified.



HORIZONTAL DATUM: Washington State Plane North, NAD83, US Survey Feet.

LEGEND:

- East Waterway Study Boundary
- MHHW line
- Construction Management Areas
- No Action (NA)
- Dredge with Residuals Management Cover
- Areas Requiring Structural Improvements

0 600
Scale in Feet

K:\Jobs\060003-PORT OF SEATTLE\060003-01\06000301-RP-043.dwg Figure 30
Dec 21, 2011 10:39am dholmer

ANCHOR QEA

Figure 30
Alternative E - Dredge All Areas Exceeding the SQS Criteria with Upland Disposal
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

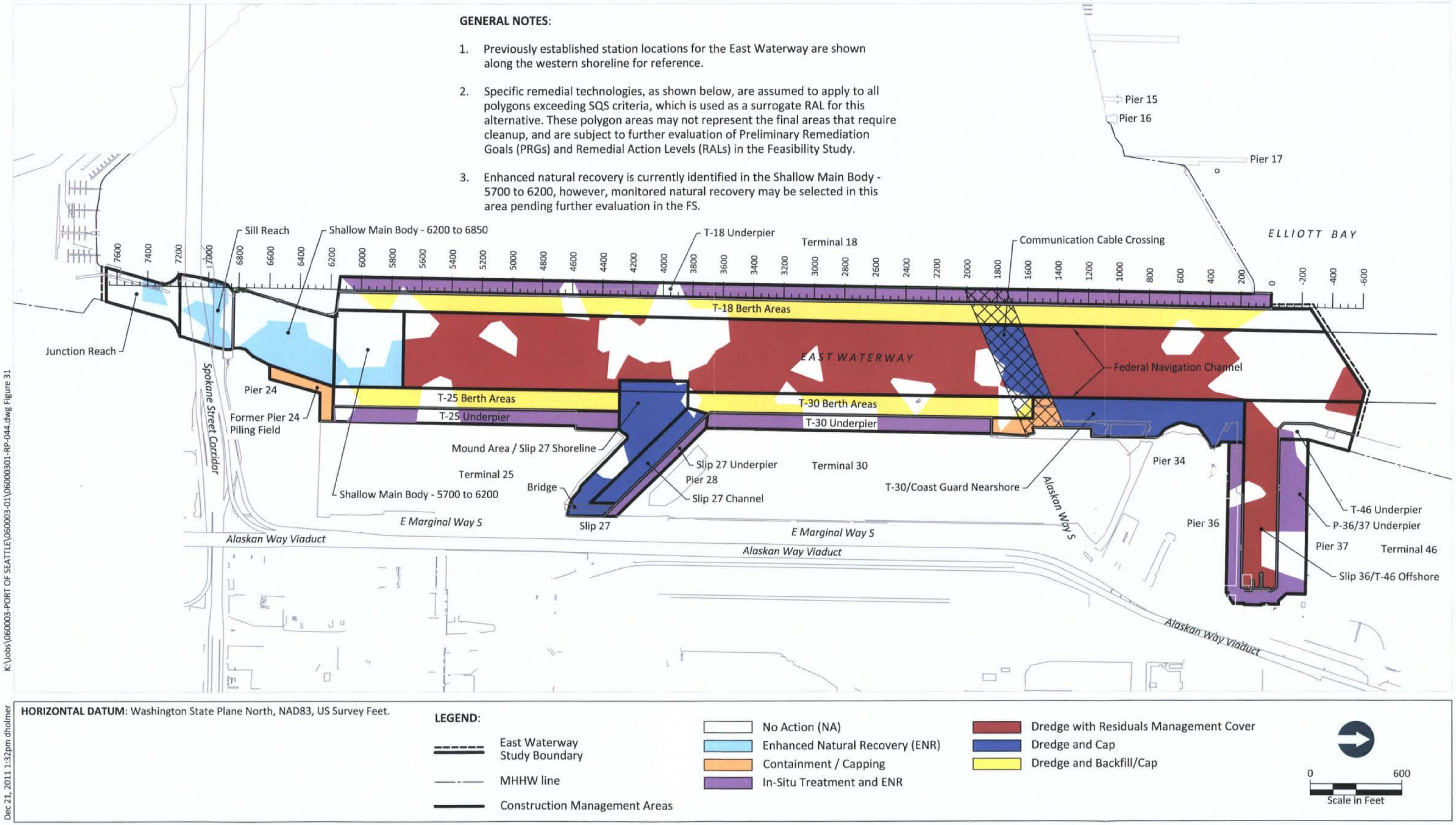


Figure 31
Alternative F - Combination Technologies by Construction Management Area
Remedial Alternative and Disposal Site Screening Memo
East Waterway SRI/FS

ANCHOR QEA

Appendix A

APPENDIX A
COST TABLES

Table A-1
Alternative A Conceptual Cost Estimate - No Action

Category	Quantity	Unit	Unit Cost	Cost	Notes
Construction and Long-Term Monitoring Costs	1	LS	$0	$0	The No Action remedial alternative represents existing conditions with no proposed remedial actions, and assumes no construction or long-term monitoring is required. The No Action alternative will be used as the baseline for comparison to other remedial alternatives.
TOTAL COST				**$0**	

Notes:

1) The assumed allowable in-water work window is October 1 through February 15.
2) Conceptual cost estimates generated for this Remedial Alternative and Disposal Site Screening Memorandum are conceptual and are not representative of FS-level cost estimates. Conceptual costs are based on best professional judgement and represent an order-of-magnitude estimate for relative cost comparison.
3) Conceptual costs associated with non-construction related items such as regulatory agency coordination and planning, engineering design, permitting, contractor procurement, sales tax, contingency, and long-term operations and maintenance are not included. These costs will be considered during development of the detailed FS.
4) The No Action remedial alternative does not include an estimated timeline for completion as no construction or long-term monitoring activities are proposed.
5) Conceptual cost estimate is based on 2011 rates and costs; no cost escalation has been applied.

Table A-2

Alternative B Conceptual Cost Estimate - Monitored Natural Recovery in All Areas Exceeding SQS Criteria

Category	Quantity	Unit	Unit Cost	Cost	Notes
Construction Costs	1	LS	$0	$0	The Monitored Natural Recovery remedial alternative does not include construction costs as no construction activities are proposed for implementation.
Long-Term Monitoring Costs					
Monitoring Event	11	LS	$400,000	$4,400,000	Monitoring events associated with this remedial alternative assume a monitoring timeframe of 30 years, with monitoring events to be completed annually for the first 5 years, at years 7 and 10, and then every 5 years thereafter.
TOTAL COST				**$4,400,000**	

Notes:

1) The assumed allowable in-water work window is October 1 through February 15.

2) Conceptual cost estimates generated for this Remedial Alternative and Disposal Site Screening Memorandum are conceptual and are not representative of FS-level cost estimates. Conceptual costs are based on best professional judgement and represent an order-of-magnitude estimate for relative cost comparison.

3) Conceptual costs associated with non-construction related items such as regulatory agency coordination and planning, engineering design, permitting, contractor procurement, sales tax, contingency, and long-term operations and maintenance are not included. These costs will be considered during development of the detailed FS.

4) For screening level purposes, the estimated timeline for long-term monitoring is 30 years.

5) Conceptual costs associated with conducting baseline and long-term RAO and O&M monitoring events include collection of samples (surface sediment, water quality, tissue, etc.), completion of analytical testing, and reporting analytical data to the regulatory agencies.

6) Conceptual cost estimate is based on 2011 rates and costs; no cost escalation has been applied.

Table A-3
Alternative C Conceptual Cost Estimate - Enhanced Natural Recovery in All Areas Exceeding SQS Criteria

Category	Quantity	Unit	Unit Cost	Cost	Notes
Construction Costs					
Mobilization/Demobilization	1	LS	$200,000	$200,000	Alternative C assumes that all construction activities can be completed within one in-water work season; mobilization/demobilization costs assume one equipment operation will be used.
Site Preparation	1	LS	$100,000	$100,000	Assumed cost for equipment preparation and implementation of site controls.
Water Quality Monitoring	5	MONTH	$30,000	$150,000	Assumes water quality monitoring will be required during completion of all construction activities.
Progress Surveys	5	MONTH	$20,000	$100,000	Estimated cost for conducting daily bathymetric progress surveys during placement of ENR material; progress surveys to be completed by the remediation contractor.
Purchase, Haul, and Place ENR Material					Assumes nominal 9-inch thickness of ENR material to be placed in all areas of the site where surface sediment concentrations exceed SQS and CSL cleanup criteria.
Open-Water Areas and Slopes	122,000	CY	$40	$4,880,000	Assumes ENR material to be placed using conventional equipment and placement techniques in open-water and slope areas. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Underpier and Difficult Access Areas	35,000	CY	$60	$2,100,000	Assumes ENR material to be placed using specialty equipment and placement techniques in under-pier and difficult access areas. Unit cost based on best professional judgement and assumes specialty equipment will be required to place ENR material beneath pier structures.
			Construction Subtotal:	***$7,530,000***	

Table A-3
Alternative C Conceptual Cost Estimate - Enhanced Natural Recovery in All Areas Exceeding SQS Criteria

Category	Quantity	Unit	Unit Cost	Cost	Notes
Long-Term Monitoring Costs					
Year 0 Baseline Event	1	LS	$400,000	$400,000	Assumes a baseline (year 0) monitoring event will be required following completion of construction activities; monitoring event cost includes effort for completion of Sediment Profile Imaging surveys and chemical testing.
Long-Term Monitoring Event	7	LS	$400,000	$2,800,000	Monitoring events associated with Alternative C assume a monitoring timeframe of 10 years, with monitoring events to be completed annually for the first 5 years, then at year 7 and year 10.
			Long-Term Monitoring Subtotal:	***$3,200,000***	
TOTAL COST				**$10,730,000**	

Notes:

1) The assumed allowable in-water work window is October 1 through February 15.
2) Conceptual cost estimates generated for this Remedial Alternative and Disposal Site Screening Memorandum are conceptual and are not representative of FS-level cost estimates. Conceptual costs are based on best professional judgement and represent an order-of-magnitude estimate for relative cost comparison.
3) Conceptual costs associated with non-construction related items such as regulatory agency coordination and planning, engineering design, permitting, contractor procurement, sales tax, contingency, and long-term operations and maintenance are not included. These costs will be considered during development of the detailed FS.
4) Enhanced Natural Recovery material volumes do not represent design volumes, and do not account for placement tolerance factors that will be established during remedial design.
5) Estimated timeline for completion of Alternative C is 5 months for construction activities and 10 years for long-term monitoring (following completion of construction). This alternative assumes one set of equipment will be required for completion of construction activities. Anticipated placement rate for ENR material is 1,500 CY/day.
6) Conceptual costs associated with conducting baseline and long-term RAO and O&M monitoring events include collection of samples (surface sediment, water quality, tissue, etc.), completion of analytical testing, and reporting analytical data to the regulatory agencies.
7) Conceptual cost estimate is based on 2011 rates and costs; no cost escalation has been applied.

Table A-4
Alternative D Conceptual Cost Estimate - Cap All Areas Exceeding SQS Criteria

Category	Quantity	Unit	Unit Cost	Cost	Notes
Construction Costs					
Mobilization/Demobilization	2	LS	$600,000	$1,200,000	Alternative D assumes that all construction activities will be completed within two in-water work seasons; mobilization/demobilization costs assume three equipment operations will be used.
Site Preparation	1	LS	$100,000	$100,000	Assumed cost for equipment preparation and implementation of site controls.
Water Quality Monitoring	8	MONTH	$30,000	$240,000	Assumes water quality monitoring will be required during completion of all construction activities.
Progress Surveys	8	MONTH	$30,000	$240,000	Estimated cost for conducting daily bathymetric progress surveys during placement of capping material; progress surveys to be completed by the remediation contractor.
Purchase, Haul, and Place Cap Material					Assumes all cap material will be placed in open-water and slope areas only where surface sediments exceed SQS and CSL cleanup criteria; no under-pier capping will be completed due to infeasibility of placement of an engineered cap in these site areas.
Attenuation Material	412,000	CY	$40	$16,480,000	Attenuation material thickness is a nominal 24 inches (2 feet) and will be placed using conventional equipment and placement techniques. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Filter Material	165,000	CY	$40	$6,600,000	Filter material thickness is a nominal 12 inches (1 foot) and will be placed using conventional equipment and placement techniques. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Armor Material	248,000	CY	$75	$18,600,000	Armor material thickness is a nominal 12 inches (1 foot) and will be placed using conventional equipment and placement techniques. Unit cost based on best professional judgement and past project experience (Scott Paper Mill Remediation).
			Construction Subtotal:	***$43,460,000***	

Table A-4
Alternative D Conceptual Cost Estimate - Cap All Areas Exceeding SQS Criteria

Category	Quantity	Unit	Unit Cost	Cost	Notes
Long-Term Monitoring Costs					
Year 0 Baseline Event	1	LS	$400,000	$400,000	Assumes a baseline (year 0) monitoring event will be required following completion of construction activities; cost estimated to be similar to Alternative C.
Long-Term Monitoring Event	7	LS	$400,000	$2,800,000	Monitoring events associated with this remedial alternative assume a monitoring timeframe of 10 years, with monitoring events to be completed annually for the first 5 years, then at year 7 and year 10; cost estimated to be similar to Alternative C.
			Long-Term Monitoring Subtotal:	***$3,200,000***	
TOTAL COST				**$46,660,000**	

Notes:

1) The assumed allowable in-water work window is October 1 through February 15.
2) Conceptual cost estimates generated for this Remedial Alternative and Disposal Site Screening Memorandum are conceptual and are not representative of FS-level cost estimates. Conceptual costs are based on best professional judgement and represent an order-of-magnitude estimate for relative cost comparison.
3) Conceptual costs associated with non-construction related items such as regulatory agency coordination and planning, engineering design, permitting, contractor procurement, sales tax, contingency, and long-term operations and maintenance are not included. These costs will be considered during development of the detailed FS.
4) Capping material volumes do not represent design volumes, and do not account for placement tolerance factors that will be established during remedial design.
5) Estimated timeline for completion of Alternative D is 8 months for construction activities and 10 years for long-term monitoring (following completion of construction). This alternative assumes three sets of equipment operating concurrently for completion of construction activities. Anticipated cap placement rate is 1,500 CY/day (per equipment set).
6) Conceptual costs associated with conducting baseline and long-term RAO and O&M monitoring events include collection of samples (surface sediment, water quality, tissue, etc.), completion of analytical testing, and reporting analytical data to the regulatory agencies.
7) Conceptual cost estimate is based on 2011 rates and costs; no cost escalation has been applied.

Table A-5

Alternative E Conceptual Cost Estimate - Dredge All Areas Exceeding the SQS Criteria with Upland Disposal

Category	Quantity	Unit	Unit Cost	Cost	Notes
Construction Costs					
Mobilization/Demobilization	3	LS	$1,400,000	$4,200,000	Alternative E assumes that all construction activities will be completed within three in-water work seasons; mobilization/demobilization costs assume two equipment operation for open-water dredging and two equipment operations for underpier dredging will be used.
Site Preparation	1	LS	$1,500,000	$1,500,000	Assumed cost for equipment preparation and implementation of site controls, including dredging best management practices (BMPs) that may be required. This cost may vary significantly and is considered a placeholder for this conceptual estimate.
Water Quality Monitoring	16	MONTH	$30,000	$480,000	Assumes water quality monitoring will be required during completion of all construction activities.
Progress Surveys	16	MONTH	$30,000	$480,000	Estimated cost for conducting daily bathymetric dredge progress surveys; progress surveys to be completed by the remediation contractor.
Mechanical Dredge, Offload, Dewater, and Handle					Assumes cost for dredging in open-water and slope areas, dewatering, and rehandling and transport of dredged material to the uplands.
Open-Water Areas and Slopes	913,000	CY	$50	$45,650,000	Assumes dredging will be completed using mechanical techniques to remove debris and contaminated sediment. Costs based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Transport and Disposal at Landfill Facility	913,000	CY	$80	$73,040,000	All dredged material and debris will be disposed of at a Subtitle D, permitted, and licensed landfill facility; no cost is included for disposal of hazardous waste. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).

Table A-5
Alternative E Conceptual Cost Estimate - Dredge All Areas Exceeding the SQS Criteria with Upland Disposal

Category	Quantity	Unit	Unit Cost	Cost	Notes
Hydraulic Dredge, Handle, and Transport					Assumes cost for specialty dredging in the under-pier and difficult access site areas, dredge water management, and transport of dredged material to the uplands.
Underpier and Difficult Access Areas	84,000	CY	$400	$33,600,000	Assumes dredging will be completed using diver-assist hydraulic equipment and that only sediment overlying existing riprap in under-pier slope areas will be removed. Unit cost based on best professional judgement and evaluation of production rates and time duration to complete the work. Conceptual costs may be highly variable.
Transport and Disposal at Landfill Facility	84,000	CY	$80	$6,720,000	All dredged material and debris will be disposed of at a Subtitle D, permitted and licensed landfill facility; no cost is included for disposal of hazardous waste. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Purchase, Haul, and Place Residuals Management Cover (RMC) Material					Assumes 6-inch nominal thickness RMC material to be placed in all areas of the site where mechanical and hydraulic dredging is completed.
Open-Water Areas and Slopes	110,000	CY	$40	$4,400,000	Assumes RMC material to be placed using conventional equipment and placement techniques in open-water and slope areas. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Underpier and Difficult Access Areas	33,000	CY	$60	$1,980,000	Assumes RMC material to be placed using specialty equipment and placement techniques in under-pier and difficult access areas. Unit cost based on best professional judgement and past project experience.
Structural and Slope Improvements and/or Replacement	1	LS	$103,330,000	$103,330,000	Allowance for structural and slope improvements and/or replacement of significant infrastructure within the majority of the East Waterway CMAs. Allowance based on order-of-magnitude cost estimates.
			Construction Subtotal:	***$275,380,000***	

Table A-5

Alternative E Conceptual Cost Estimate - Dredge All Areas Exceeding the SQS Criteria with Upland Disposal

Category	Quantity	Unit	Unit Cost	Cost	Notes
Long-Term Monitoring Costs					
Year 0 Baseline Event	1	LS	$400,000	$400,000	Alternative E assumes that a post-remediation sampling event will be performed.
Long-Term Monitoring Event	0	LS	$0	$0	Alternative E assumes that all contamination is removed from the site, and that no long-term monitoring effort will be required.
Long-Term Monitoring Subtotal:				***$400,000***	
TOTAL COST				**$275,780,000**	

Notes:

1) The assumed allowable in-water work window is October 1 through February 15.

2) Conceptual cost estimates generated for this Remedial Alternative and Disposal Site Screening Memorandum are conceptual and are not representative of FS-level cost estimates. Conceptual costs are based on best professional judgement and represent an order-of-magnitude estimate for relative cost comparison.

3) Conceptual costs associated with non-construction related items such as regulatory agency coordination and planning, engineering design, permitting, contractor procurement, sales tax, contingency, and long-term operations and maintenance are not included. These costs will be considered during development of the detailed FS.

4) Dredge material volumes include a design factor of 1.5 times the calculated removal volume to account for design of the dredge prism, slope transitions, and dredge allowances.

5) Order of magnitude cost estimates for infrastructure repair and/or replacement were performed for structures located within the Shallow Main Body, Former Pier 24 Piling Field, Sill Reach, Berth Area, Slip 27 Channel/Pier 28, Slip 36/T-36 Offshore, and T-30/USCG Nearshore CMAs.

6) Conceptual costs associated with conducting baseline and long-term RAO and O&M monitoring events include collection of samples (surface sediment, water quality, tissue, etc.), completion of analytical testing, and reporting analytical data to the regulatory agencies.

7) Estimated timeline for completion of Alternative E is 13 months for construction activities; no long-term monitoring effort is required for implementation of this remedial alternative. This alternative assumes two sets of open-water and under-pier dredging equipment will be required for completion of construction activities. Anticipated open-water dredging rate is 1,500 CY/day; under-pier dredging rate is 50 CY/day.

8) Conceptual cost estimate is based on 2011 rates and costs; no cost escalation has been applied.

Table A-6

Alternative F Conceptual Cost Estimate - Combination Technologies by Construction Management Area

Category	Quantity	Unit	Unit Cost	Cost	Notes
Construction Costs					
Mobilization/Demobilization	3	LS	$1,000,000	$3,000,000	Alternative F assumes that all construction activities will be completed within three in-water work seasons; mobilization/demobilization costs assume two equipment operations will be used for dredging and one equipment operation will be used for all other remediation activities.
Site Preparation	1	LS	$1,500,000	$1,500,000	Assumed cost for equipment preparation and implementation of site controls, including dredging best management practices (BMPs) that may be required. This cost may vary significantly and is considered a placeholder for this conceptual estimate.
Water Quality Monitoring	14	MONTH	$30,000	$420,000	Assumes water quality monitoring will be required during completion of all construction activities.
Progress Surveys	14	MONTH	$30,000	$420,000	Estimated cost for conducting daily bathymetric dredge progress surveys; progress surveys to be completed by the remediation contractor.
Purchase, Haul, and Place ENR Material					Assumes nominal 9-inch thickness of ENR material to be placed in all areas of the site where surface sediment concentrations exceed SQS and CSL cleanup criteria.
Open-Water Areas and Slopes	7,000	CY	$40	$280,000	Assumes ENR material to be placed using conventional equipment and placement techniques in open-water and slope areas. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Underpier and Difficult Access Areas	25,000	CY	$60	$1,500,000	Assumes ENR material to be placed using specialty equipment and placement techniques in under-pier and difficult access areas. Unit cost based on best professional judgement and assumes specialty equipment will be required to place ENR material beneath pier structures.

Table A-6
Alternative F Conceptual Cost Estimate - Combination Technologies by Construction Management Area

Category	Quantity	Unit	Unit Cost	Cost	Notes
Purchase, Haul, and Place Granulated Activated Carbon (GAC) Material					Assumes GAC material will be mixed with sand (according to specifications to be established during design), and placed in under-pier areas where surface sediments exceed SQS and CSL cleanup criteria.
Underpier Areas	7,000	CY	$250	$1,750,000	Assumes GAC-sand mix material to be placed using specialty equipment and placement techniques in under-pier areas. Conceptual cost is based on review of existing literature, and may be highly variable.
Mechanical Dredge, Offload, Dewater, and Handle					Assumes cost for dredging in open-water and slope areas where surface sediments exceed SQS and CSL cleanup criteria, dewatering, and rehandling and transport of dredged material to the uplands.
Open-Water Areas and Slopes	744,000	CY	$50	$37,200,000	Assumes dredging will be completed using mechanical techniques to remove debris and contaminated sediment. Costs based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Transport and Disposal at Landfill Facility	744,000	CY	$80	$59,520,000	All dredged material and debris will be disposed of at a Subtitle D, permitted, and licensed landfill facility; no cost is included for disposal of hazardous waste. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Purchase, Haul, and Place Residuals Management Cover (RMC) Material					Assumes 6-inch nominal thickness of RMC material to be placed in all areas of the site where mechanical dredging is completed.
Open-Water Areas and Slopes	42,000	CY	$40	$1,680,000	Assumes RMC material to be placed using conventional equipment and placement techniques in open-water and slope areas. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).

Table A-6

Alternative F Conceptual Cost Estimate - Combination Technologies by Construction Management Area

Category	Quantity	Unit	Unit Cost	Cost	Notes
Purchase, Haul, and Place Cap Material					Assumes all cap material will be placed in open-water and slope areas only where surface sediments exceed SQS and CSL cleanup criteria; no under-pier capping will be completed due to infeasibility of placement of an engineered cap in these site areas.
Attenuation Material	90,000	CY	$40	$3,600,000	Attenuation material thickness is a nominal 24 inches (2 feet) and will be placed using conventional equipment and placement techniques. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Filter Material	36,000	CY	$40	$1,440,000	Filter material thickness is a nominal 12 inches (1 foot) and will be placed using conventional equipment and placement techniques. Unit cost based on best professional judgement and recent project experience (Port of Olympia, Denny Way CSO Remediation, Scott Paper Mill Remediation).
Armor Material	54,000	CY	$75	$4,050,000	Armor material thickness is a nominal 12 inches (1 foot) and will be placed using conventional equipment and placement techniques. Unit cost based on best professional judgement and past project experience (Scott Paper Mill Remediation).
Purchase, Haul, and Place Backfill Material					Backfill material to be placed in berth areas where dredging cuts are less than 5 feet in thickness.
Sand in Berth Areas	52,000	CY	$40	$2,080,000	Backfill material will be clean sand and placed using conventional equipment and placement methods to restore pre-dredge mudline elevations in the berth CMAs. Unit cost based on best professional judgement and past project experience (Scott Paper Mill Remediation).
			Construction Subtotal:	***$118,440,000***	

Table A-6
Alternative F Conceptual Cost Estimate - Combination Technologies by Construction Management Area

Category	Quantity	Unit	Unit Cost	Cost	Notes
Long-Term Monitoring Costs					
Year 0 Baseline Event (ENR and Capping)	1	LS	$400,000	$400,000	Assumes a baseline (year 0) monitoring event will be required following completion of ENR and capping construction activities; monitoring event cost includes effort for completion of Sediment Profile Imaging surveys.
Long-Term Monitoring Event (ENR and Capping)	7	LS	$400,000	$2,800,000	Monitoring events associated with ENR and Capping assume a monitoring timeframe of 10 years, with monitoring events to be completed annually for the first 5 years, then at year 7 and year 10.
Long-Term Monitoring Event (MNR)	11	LS	$400,000	$4,400,000	Monitoring events associated with MNR assume a monitoring timeframe of 30 years, with monitoring events to be completed annually for the first 5 years, at years 7 and 10, and then every 5 years thereafter.
			Long-Term Monitoring Subtotal:	***$7,600,000***	
TOTAL COST				**$126,040,000**	

Notes:

1) The assumed allowable in-water work window is October 1 through February 15.
2) Conceptual cost estimates generated for this Draft Remedial Alternative and Disposal Site Screening Memorandum are conceptual and are not representative of FS-level cost estimates. Conceptual costs are based on best professional judgement and represent an order-of-magnitude estimate for relative cost comparison.
3) Conceptual costs associated with non-construction related items such as regulatory agency coordination and planning, engineering design, permitting, contractor procurement, sales tax, contingency, and long-term operations and maintenance are not included. These costs will be considered during development of the detailed FS.
4) Dredge material volumes include a design factor of 1.5 times the calculated removal volume to account for design of the dredge prism, slope transitions, and dredge allowances.
5) Estimated timeline for completion of Alternative F is 14 months for construction activities, and up to 30 years for long-term monitoring (following completion of construction). This alternative assumes two sets of equipment will be required for completion of dredging activities, and one set of equipment will be required for all other construction activities. Anticipated production rates are 1,500 CY/day for all activities.
6) Capping material volumes do not represent design volumes, and do not account for placement tolerance factors that will be established during remedial design.
7) Enhanced Natural Recovery material volumes do not represent design volumes, and do not account for placement tolerance factors that will be established during remedial design.
8) Conceptual costs associated with conducting baseline and long-term RAO and O&M monitoring events include collection of samples (surface sediment, water quality, tissue, etc.), completion of analytical testing, and reporting analytical data to the regulatory agencies.
9) Conceptual cost estimate is based on 2011 rates and costs; no cost escalation has been applied.

Backup to Table A-5
Order of Magnitude Opinion of Probable Construction Costs for Alternative E
East Waterway RIFS Structural Improvements
July 26, 2011

kpff
Consulting Engineers

Location Item		Cost (2011 $)
Junction Reach	$	-
Sill Reach	$	24,526,000
Shallow Main Body	$	3,403,000
Former Pier 24 Piling Field	$	4,050,000
Unmaintained Main Body	$	-
Federal Navigation Channel	$	-
Underpier Areas	$	-
Berth Areas (T18, T-25, T30)	$	18,235,000
Slip 27 Channel/Pier 28	$	24,225,000
Slip 36/T-46 Offshore	$	2,500,000
Mound Area/Slip 27 Shoreline	$	-
T-30/USCG Nearshore	$	2,542,000
Communication Cable Crossing	$	-
Subtotal Structural Construction Cost	$	79,481,000
Contingency (30%)	$	23,844,000
Total ROM Estimate	**$**	**103,330,000**